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A study of the effects of paper, ink and drying techniques on lithographic ink transfers during electrophotographic imprinting

Lisa Rentschler

A STUDY OF THE EFFECTS OF PAPER, INK AND DRYING TECHNIQUES ON LITHOGRAPHIC INK TRANSFER DURING ELECTROPHOTOGRAPHIC IMPRINTING

by

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A STUDY OF THE EFFECTS OF PAPER, INK AND DRYING TECHNIQUES ON LITHOGRAPHIC INK TRANSFER DURING ELECTROPHOTOGRAPHIC IMPRINTING.

Certificate of Approval -- Master's Thesis

School of Printing
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CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's Thesis of
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has been approved by the Thesis Committee as satisfactory for the thesis requirement for the Master of Science degree.

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DEDICATION

Without the continual support of my family and friends this thesis would not have been completed. Time and space prohibit me from thanking everyone who helped me survive this process.

This thesis is dedicated to my family, John, Barbara, Jay, Laurie, Linda, Dave, Paula, Garrett, Susan, John (my buddy), Jason and Baby Tobe. And especially my partner, Bill. They share their strength with me.

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ABSTRACT

Product end use dictates the materials used to produce a printed piece. If flexographic printers are purchasing ink for a packaging carton job, they don't choose a scuff prone ink. The same should be true for printers producing letterheads for subsequent use in electrophotographic equipment.

Electrophotography is an image transfer process that uses the principles of electrostatics. An Ektaprint 200 copier/duplicator charges the surface of a sheet exposing an image area, develops that image, affixes toner to that image and then mechanically traps the toner to the surface of the substrate using heat and/or pressure. When a lithographically printed letterhead is subject to the heat of a fuser roller, it can cause the ink to resoften and subsequently transfer to the next sheets passing through the copier, an undesirable effect.

This experiment tested various ink/paper/drying combinations to determine whether or not specific print conditions affect the transfer of lithographic ink during electrophotographic imprinting.

A test form was designed to include all the images typically printed on a letterhead. Each test sample was first printed under controlled conditions and then run through an Ektaprint 200 copier/duplicator. Visual assessment was used to evaluate test samples. The presence

or absence of image transfer determined whether or not the null hypothesis was rejected. A Wilcoxon sign test was used to determine whether or not a test sample could be evaluated. A level of .05 significance was obtained in two cases. These samples were excluded from the results.

Densitometric readings were taken to determine the severity of the lithographic image transfer. Various ink and paper characteristics were evaluated using descriptive statistics.

Twenty-one print conditions exhibited no visual image transfer when processed in the Ektaprint 200. These ink/paper/drying conditions could guide printers of letter- heads which are to be subsequently processed in electro-photographic equipment.

CHAPTER ONE

INTRODUCTION

The offset lithographic process is a common method used to print business stationery. This printing method generally produces a visually acceptable reproduction for a reasonable price. Lithography also offers the client the option to use thermography, a popular print design for letterhead stationery. (1)

Craftsmanship is necessary to reproduce consistent, defect-free results when printing with offset lithography. Of the variables affecting the production of a lithographic product one of the most important is the ink/paper relationship. The success or failure of any printing project relies greatly on ink/paper interaction. "As printing has become more and more a high-tech industry, advances in equipment have demanded parallel progress in the development of inks and papers. New or improved printing processes, higher press speeds, environmental concerns and a proliferation of different end uses for printed products are just a few of the variables that make the relationship between inks and paper a critical consideration for every printer." (2)

As Vincent Bellini points out, product end use complicates the selection of ink and paper. One end use for a lithographically printed letterhead is subsequent imprinting in an electrophotographic copier machine.

Electrophotography is an image transfer process that requires six steps to adhere toner to a paper's surface: "1) electrostatic charging, 2) optical exposure, 3) development of the electrostatic image, 4) transfer, 5) fixing, and 6) cleaning the residual image from the photoconductor." (3) "Fixing" the toner to the surface of the paper requires heat. Temperatures range from 340 to 400 degrees Fahrenheit. Even though this heat is necessary to fuse the toner to the paper by use of rollers (see Figure 1), it can have some negative effects on lithographic inks commonly used to print letterheads.

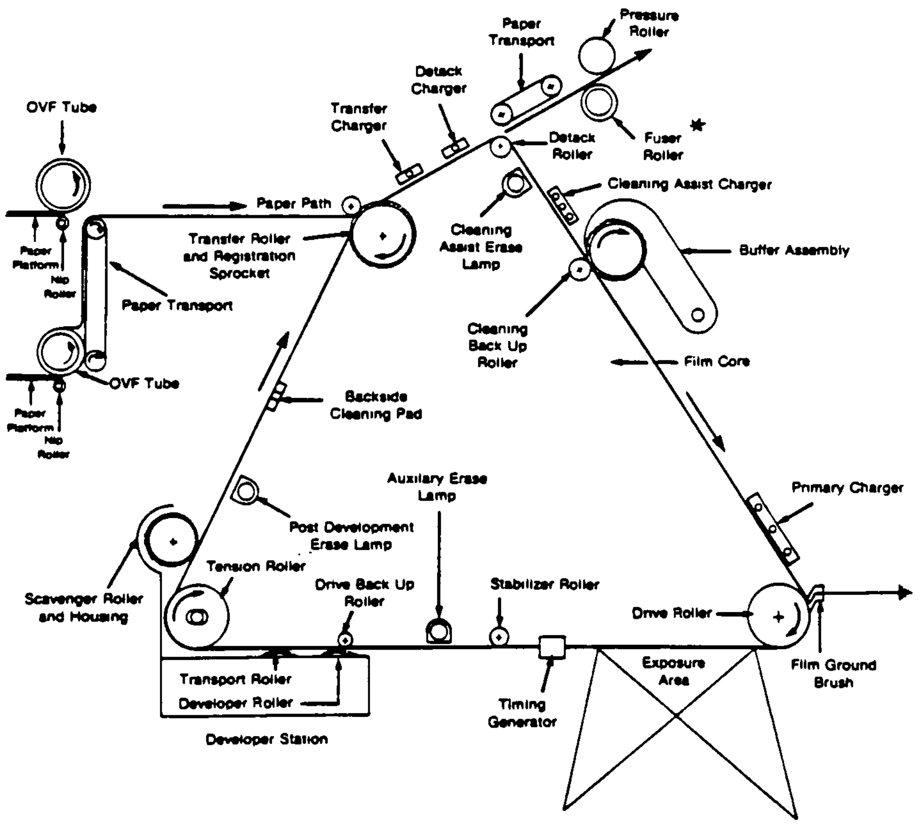

Figure 1. A schema of the Ektaprint 200 copier

Despite these facts, companies continue to use electrophotography (also known as xerography) as a convenient, inexpensive method of imprinting letterheads. "Recent figures show that xerography, though it's been around a long time, is still an important system and the paper consumption associated with this process is growing at a 4 to 6 percent Compounded Annual Growth Rate (CAGR)." (4) In fact, many companies now consider copier machine output suitable for distribution to their clients as publication materials. (5)

The electrophotographic process can promote lithographic ink transfer which in turn reprints the preprinted letterhead design onto the copier's fuser roller and in turn transfers the image onto the next sheet through the copier. (6) Apparently, what was thought to be a dry, lithographic ink film softens and transfers to areas where it does not belong.

This research study concerned itself with the effects of selected inks, papers and drying conditions of lithographically printed letterheads on the transfer of lithographic inks during electrophotographic imprinting. By controlling these three variables it was hoped that it could be ascertained whether certain conditions prevented image transfer during electrophotographic imprinting while other conditions promoted it.

A similar ink transfer problem associated with lithography is ink set-off. Lithographic ink set-off "occurs when too much ink is run, when the ink is too soft, or when the ink does not set quickly enough." (7) Paper properties also affect set-off, "if the paper is not properly absorbent, the ink will not set fast enough." (8) The lithographic ink set-off problem may provide insight into image transfer during electrophotographic imprinting. There-fore, it was a theoretical bases for this research study.

The temperatures in a fuser-type electrophotographic copier can reach 400 degrees Fahrenheit, and the pressure can be as high as 43 pounds per square inch (psi). (9) While both these factors may affect the image transfer problem, it would be difficult to change the mechanics of existing office reproduction machines. This research concentrated on the interaction of those printing variables that could possibly prevent lithographic image transfer during electrophotographic imprinting rather than the mechanics of an electrophotographic copier which may have contributed to the image transfer problem. The research emphasized ink/paper interaction, ink setting and drying characteristics, and how these factors affected lithographic image transfer during electrophotographic imprinting.

The complexity of these factors necessitated that this research be a pilot study. The "whats" of ink, paper and drying conditions were examined, not the "whys."

The methodology involved printing a predetermined test form on all combinations of four substrates appropriate for business stationery printing, with four black, lithographic sheetfed inks that could be run on a single color duplicator, and then drying those samples by oxidation, enhanced oxidation, forced air heating, and a microwave oven. This yielded a three factor, four level factorial (4^3) experimental design with 64 different test samples. Appendix A presents the experimental design in graphic form.

After printing and drying, a systematic sampling of each test had a short, typed form letter electrophoto- graphically imprinted on it using the Kodak Ektaprint 200 copier/duplicator. Two ink and four paper characteristics were measured. Scatter diagrams were used to evaluate the positive or negative linear relationship between two given variables, where applicable. If scatter diagrams were not applicable, data was presented in tables which appear in Appendix E. All data relevant to the study are included in the appendices.

The Wilcoxon sign test is a statistical test to determine if the frequency of occurrence for two variables is identical. In this study the preference for print conditions to affect the transfer of lithographic images during electrophotographic imprinting was tested. If the sample satisfied the conditions for preference, it was then accepted or rejected per the hypothesis as stated in Chapter Four.

Both relative humidity and temperature affect ink drying. (10) Because the environment of the pressroom could not be controlled, the relative humidity and temperature were monitored. There were no aberrations in temperature or humidity to be noted.

Paper samples which were removed from the pressroom were stored in plastic bags to control temperature and humidity. Press conditions remained consistent; test form image, fountain solution, blanket, plate, blanket to plate packing, etc. Tests were run using black lithographic sheetfed inks on white papers.

The result of this research may provide the printer, print buyer or graphic designer with some practical guidelines on which ink, paper and drying conditions to use when printing letterheads which subsequently undergo electrophotographic imprinting. The end use of the product should dictate ink and paper choice to ensure the production of a defect-free, commercially acceptable product. Hopefully this research will provide relevant information for better decision making in the production of print matter which will be used in electrophotographic copiers.

A Statement of the Problem follows the Introduction and concludes Chapter One. The theoretical bases of the study and the review of the literature are discussed in Chapter Two. Chapter Three contains the hypothesis and rationale for the research study. The structure of the research methodology and statistical analyses are found in Chapter Four. Results and conclusions of the research are analyzed in Chapter Five. Chapter Six outlines this researcher's recommendations.

Statement of the Problem

The use of letterheads printed using lithography as a medium for electrophotographic imprinting can yield results which are unacceptable to the end user. This can be due to image transfer of the lithographic ink onto the non-image area of the printed sheet when the offset sheet is subsequently imprinted in an electrophotographic copier.

The purpose of this research was to determine if a given combination of ink, paper and drying conditions used in the lithographic process affects image transfer during electrophotographic imprinting. Careful selection of materials commonly used to print business papers for an end use as electrophotographic substrates was considered along with certain drying techniques to determine if image transfer is significantly reduced when these factors are controlled.

ENDNOTES

CHAPTER ONE

(1) The Graphic Arts Manual, 1980, Musarts Publishing Corp., New York, p.426.

(2) Vincent Bellini, "Matching Ink to Paper," Canadian Printer and Publisher, April 1985, Vol. 95, No. 5, p. 41.

(3) George R. Mott, "Unconventional Image Forming Systems in the Graphic Arts -- Electrophotography," in TAGA Proceedings 1965, p. 474.

(4) Mark Manske, "Paper's Impact on Toner-Based Non-Impact Printing Systems," Form, October 1987, p. 98.

(5) "Copiers: Not Just Office Products Anymore," In-Plant Reproduction, November 1987, Vol. 37, No. 11, p.43.

(6) Conversation with Frank Foley, Eastman Kodak Company, 21 December 1987.

(7) Raymond N. Blair (ed.), The Lithographer's Manual, 7th ed., 1983, Graphic Arts Technical Association, Pittsburgh, Pa., p. 13:11.

(8) Ibid, p. 13:27.

(9) R.M. Schaffert, Electrophotography, 1965, The Focal Press, London.

(10) E.A. Apps, Inks for the Major Printing Processes, 1963, Leonard Hills, London, p. 199.

CHAPTER TWO

THEORETICAL BASES FOR THE RESEARCH AND A REVIEW OF THE LITERATURE

Much of the scientific research on lithographic ink set-off focuses on inks used in the offset process and coated paper stocks. The very nature of coated paper, "a smooth, non-fibrous surface" (1) inhibits the adhesion of ink to the paper's surface. If the ink does not adhere, it cannot set or dry properly.

In 1985, Flint Ink and S.D. Warren conducted a joint research project to study ink/paper/fountain solution interactions. One of the tests studied the ink set time (IST) of paper. "The ink set time is defined as the amount of time required to prevent set-off from occurring. IST of 30-200 seconds is considered fast. Anything greater than 1000 seconds is slow and generally set-off problems occur." (2) The researchers used two different 60lb. coated sheets in the experiment. One had a high IST and the other had a low IST.

Eight experimental runs were made by a commercial printer on a Harris M-110 web-fed press. Unfortunately, the ink set times were not evaluated because "...we could not get acceptable prints for all combinations of the high IST paper..." (3) Although ink set time was not evaluated, the on-line experimental environment is significant. The researchers concluded that "experimental design is applicable to commercial print trials." (4) One aim of this experiment was to attempt to make the research environment as similar to typical production conditions as possible.

Larsson and Sunnerberg studied the influence of ink concentration change and ink penetration into the paper structure on "the set-off resistance and the rub-off resistance of the printed ink layer." (5) They studied newsprint, a highly absorptive stock, and a coated paper with a surface structure so fine that "separation of the ink into its main components occurred at the surface". (6)

Set-off was simulated using a specially designed proof press. The proof press was chosen because the mechanical principles of the press are similar to letterpress used in newspaper printing at that time. They measured set-off as the amount of pigment transferred to a receiving surface in given time increments after printing.

They concluded that the amount of pigment transferred by set-off decreased as time passed. This was true for newsprint and the coated paper and both test inks.

In 1955, Norman J. Beckman of the Kimberly-Clark Research and Development Center presented a Technical Association of the Graphic Arts paper on "The Measurement of the Drying of Letterpress and Lithographic Inks on Coated Book Papers." (7) Beckman stated that "wet ink film applied to the paper at the moment of impression must undergo physical and chemical changes which render the printed image indelible to all normal handling conditions during and subsequent to printing." (8)

Beckman divided drying studies into several categories. One of which recommended that the understanding of ink drying is facilitated by conducting experiments which study the effect of ink on paper where a variety of ink/paper combinations are tested.

Beckman recommended the use of the IGT Drying Time Recorder as a "simple instrument suitable for ink drying measurement on paper. The light transmission of ink set-off from a wet print to a standard chart of clear cellulose acetate under a standard load is taken as a measure of ink drying." (9) The IGT chart was evaluated with a Bausch and Lomb Opacimeter.

Beckman tested 10 different paper samples and 17 different ink samples. He measured felt vs. wire side printing as related to drying time, paper coated one side and paper coated two sides and their drying times, drying on different days and drying time as affected by varied drier content of ink and drying atmosphere.

In Beckman's conclusions he stated that his research was "largely of a survey nature." (10) Beckman contended that his research "provides valuable orientation material for paper research and quality control applications regarding ink drying problems." (11) A number of Beckman's recommendations were used as the basis of the current study. While Beckman used the Bausch and Lomb Opacimeter to evaluate the amount of ink transfer, this research was more suited to the use of a Gretag reflection densitometer and visual assessment to determine image transfer on the imprinted test sheet samples.

In a 1960 TAPPI JOURNAL, Joseph Krause discussed the printability of paper and its relation to ink drying. Krause contended that the available research has "raised more questions than answers." (12)

Krause's article pointed out that rag bond and ledger paper "not only need more drier, but in many instances may necessitate the use of synthetic resin based vehicles." (13) Krause further noted that drying problems can be traced to "the insolublization of driers in the ink by the acidity of the paper during periods of high humidity." (14)

Ink researchers agree. E.A. Apps wrote that "the acidity of paper has a pronounced effect on the drying time of ink, particularly under damp conditions. This fact should be remembered when...printing lithographic inks." (15) Apps also noted that ink drying can be slowed by paper with acidic pH readings.

The paper/ink relationship was only part of the problem under consideration. After a sheet had been printed and dried, it must not be affected by the toners and imprinting conditions that exist in electrophotographic copying.

For example, a copier paper should contain low moisture content to ensure good runnability. (16)

Specially manufactured xerographic papers have proven to be more reliable when using electrophotographic imprinting than those developed for use in offset lithography. According to the Xerox Corporation, electrophotographic copiers have "less 'tuning' latitude than an offset press; instead reliability is optimized through the proper selection of throughput stock." (17) Several grades of xerographic papers were suitable for offset printing and conform to the generally accepted standards that dictate stationery selection.

Sheetfed lithographic inks usually set as a result of penetration and then dry by oxidation and/or polymerization. A set ink is an ink which resists smearing or transferring pigment to the press operator's finger or to another sheet of paper. After the oil component of a sheetfed lithographic ink penetrates the substrate, the vehicle dries by oxidation, mechanically trapping the pigment in the porous paper surface.

The setting and drying of sheetfed inks can be enhanced through the application of heat. "Since most chemical reactions are accelerated as temperature increases, the oxidate [sic] polymerization reaction, by which sheetfed inks dry, goes faster when the print is warmed." (18) While heat can significantly decrease setting and drying times, it has the disadvantage of "the possibility of thermal degradation of paper coatings due to absorption of the radiation in the unprinted areas...which can cause discoloration and brittleness." (19) Each of the mentioned factors could affect image transfer during the electrophotographic process.

This research was intended to act as a pilot study, hopefully isolating one or more variables for future investigation.

ENDNOTES

CHAPTER TWO

(1) The Graphic Arts Manual, 1980, Musarts Publishing Corp., New York, p. 459.

(2) Joseph Koniecki, et al, "Ink/Paper/Fountain Solution Interaction," in TAGA Proceedings 1985, p. 261.

(3) Ibid, p. 264.

(4) Ibid, p. 268.

(5) Lars O. Larsson & Gunnar Sunnerberg, "Post-Printing Changes in Printed Ink-Layers and Their Effect on Smearing," in TAGA Proceedings 1972, p. 405.

(6) Ibid, p. 407.

(7) Norman J. Beckman, "The Measurement of the Drying of Letterpress and Lithographic Inks on Coated Book Papers," in TAGA Proceedings 1955, p. 154.

(8) Ibid, p. 154.

(9) Ibid, p. 155.

(10) Ibid, p. 169.

(11) Ibid, p. 169.

(12) Joseph Krause, "The Influence of Paper Surface Characteristics on Printing Inks and Their Formulations," TAPPI, 1960, vol. 43, no. 7, p. 213A.

(13) Ibid, p. 213A.

(14) Ibid, p. 214A.

(15) E.A. Apps, Inks for the Major Printing Processes, 1963, Leonard Hill, London, p. 67.

(16) Helpful Facts About Paper, Xerox Corporation, p.11.

(17) Ibid, p. 7.

(18) GATF Technical Service Report, 1979, no. 7225, p. 2

(19) "Comparison of Inks and Curing Methods," High Volume Printing, October/November 1985, p. 47

CHAPTER THREE

HYPOTHESIS AND RATIONALE

The problem has been stated as a need to determine if specific combinations of lithographic inks, paper, and drying techniques influence the transfer of lithographic ink from the printed image to the fuser roller of an electrophotographic copier to the non-image area of the next sheet through the fuser roller. In this case, the following hypothesis is appropriate for each of the sixty-four combinations of test inks, papers and drying conditions (as described in Chapter Four). The hypothesis is stated as follows: An image printed on an offset press with a specific lithographic ink, substrate and using a specific drying technique will not transfer onto the next sheet when imprinted in an electrophotographic copier.

If the hypothesis is rejected, the researcher will then conclude that certain combinations of ink, paper and drying are unfavorable for use in electrophotographic imprinting.

CHAPTER FOUR

METHODOLOGY

To determine if specific combinations of sheetfed lithographic ink, paper and drying conditions affect image transfer when imprinting in an electrophotographic copier, a three factor, four level experiment was used. The three factors were ink, paper and drying conditions. Four levels of each factor were represented by the papers tested. The four paper tests were: Xerox 4024 Dual Purpose 20 pound; Xerox XXV Archival Bond 20 pound, 25% cotton content bond; Gilbert Neu-Tech 20 pound, 25% cotton content bond; and Hammermill 50 pound offset. The four inks were: Van Son Rubber Base Plus; Van Son CML Oil Base Plus (a quickset ink); Van Son Tough Tex; and Kohl Madden Offset I.T. (a quickset ink). The four drying techniques were: 24 hour oxidation; enhanced oxidation (seven days); forced air heat drying; and microwave drying in a Sanyo 700 watt microwave oven.

The samples were printed one side only, parallel to the paper's grain, on 8 1/2" x 11" sheets at the Rochester Institute of Technology's Lithography lab by an experienced press operator on an Itek 960 Offset Duplicator. The image on the test plate included a 60 pt. Bodoni Ultra Bold, a serif typeface, an 18 pt. Futura, a sans serif typeface, an eight pt. rule, a two pt. rule, 25%, 50% and 75% screen tints and a simple graphic image. (See Appendix B) The variations in point sizes and font designs were chosen to determine if type design and/or size has an affect on image transfer. Screen tints were included to ascertain if a screened image was less likely to transfer than a solid one.

The image was exposed on a 3M Viking negative working aluminum plate. A slightly acidic fountain solution was used to simulate commercial print shop conditions.

After the press runs were completed and the inks dried, every fifth sheet from each run was extracted for a sample set of 30. A short, typed form letter was imprinted on the sample sets using a Kodak Ektaprint 200 copier/duplicator at the Eastman Kodak Company's Paper Technology Development laboratories. Between each sample set tested a minimum of six to a maximum of 50 sheets of blank paper were fed through the copier to clean any ambient lithographic ink from the fuser rollers. The cleaning wick was periodically inspected for excessive ink build-up.

The sheets that were imprinted in the copier were visually evaluated by this researcher and two Kodak researchers to detect image transfer, if any. Subsequent density readings of visually detected image transfer stains were made on the Gretag 186 reflection densitometer. Any sample exhibiting the slightest degree of image transfer by visual detection was considered to represent an image transfer situation and was included in the statistical analysis.

The preference for print conditions to affect lithographic image transfer results was evaluated using nonparametric statistics. A Wilcoxon sign test was used. In addition to the preference for lithographic image transfer, certain ink and paper characteristics were evaluated graphically: ink tack, % ink solids, paper moisture content. Other paper characteristics were tested and were presented in Chapter Five: paper pH, paper curl and paper absorptivity. The former set of tests were evaluated through the use of scatter diagrams to determine if there was a linear relationship between the ink or paper characteristic and the test conditions.

Paper

Two selection criteria were used to determine the paper stocks. The first selection criterion determined if the selected papers were suitable for use in the lithographic printing process. The second criterion was to use papers that possess good electrophotographic runnability characteristics.

Xerox 4024 Dual Purpose is a 20 pound, number 4 sulphite bond paper. It has good strength characteristics and good opacity. The paper was manufactured for use in electrophotographic copiers and to perform well on offset equipment.

Xerox XXV Archival Bond Paper is a 20 pound, 25% cotton content bond that is extra bright and is acid free. Xerox noted that papers that are not 100% wood pulp run less consistently, that is cause paper jams, in electrophotographic copiers. However, it should run as well as any bond paper on the offset duplicator.

Gilbert Lancaster Neu-Tech 25% cotton bond is a high quality business paper with a slightly smoother surface than other cotton bonds. The specially formulated smooth surface of the paper improves its ability to adhere toners to its surface.

Hammermill 50 pound offset stock was the last test paper. It was chosen for its common commercial use (as noted by a major paper distributor in Rochester) in small offset duplicators, similar to the Itek 960. Offset papers generally have a higher moisture content than the other papers in this study which could contribute to excessive curl during the Ektaprint copier run.

Inks

Inks were chosen based on conversations with ink manufacturers and on the popularity of certain inks for printing stationery. As consistent an ink film thickness and solid ink density as possible were maintained throughout the press runs.

Van Son Rubber Base Plus is commonly used to print letterheads. Rubber based inks generally have a long open time; that is they don't dry quickly on ink rollers. They are inexpensive and easy to use. However, rubber based inks never dry; they merely penetrate the paper's surface and set.

The Van Son CML Oil Base and Kohl Madden Offset I.T. are quickset inks specially formulated to be dry to the touch within a few minutes of application. They work well on coated papers, but they perform most effectively on absorbent stocks. The first phase of drying is the penetration of the oil and solvent into the structure of the paper fibers followed by the drying of the resin left on the paper's surface. These inks can contribute to emulsification problems on small, offset duplicators.

The Van Son Tough Tex is a high percent solids ink. It has poor open time on the press, drying within 30 minutes on the ink train. It dries by oxidation, and possesses rapid drying characteristics. Tough Tex is thought to be a good ink for printing jobs that will be subsequently imprinted electrophotographically because it resists resoftening.

Drying Techniques

Most lithographic inks contain solvents which are used to change the viscosity of the ink. The initial change in viscosity is known as setting. Setting precedes the drying of a lithographic sheetfed ink. Ink film drying occurs through the chemical reactions of oxidation/polymerization. Inks can soften and transfer when the proper conditions exist. By controlling paper, ink and drying it was hoped that one could isolate the paper, ink and drying conditions under which ink would or would not transfer.

Oxidation is the phase of drying whereby an ink's components absorb oxygen from the air causing their basic structure to undergo transformation from a liquid state to a solid one. As oxidation occurs, small molecular units crosslink to create larger molecular chains which are difficult to unlink. This is known as polymerization. When this chemical reaction is complete, the fluid ink has solidified, or "dried."

In this experiment, the first set of paper samples were air dried for 24 hours in the pressroom environment before the systematic sampling and testing in the Kodak Ektaprint 200 copier/duplicator occurred. This was called the "oxidation" drying technique.

A second oxidation test required seven days of air drying in the Eastman Kodak paper lab's environment. The standard relative humidity was 50% (plus or minus 2%) and the standard temperature was 68 degrees Fahrenheit (plus or minus 2 degrees Fahrenheit). The paper was stored unwrapped on a shelf in the climatically controlled paper laboratory. This was called the "enhanced oxidation" drying factor.

The third drying technique impinged forced hot air on the individual test sheets in a Partlow Forced Air Dryer set at 110 degrees Fahrenheit with a dwell time of 40 seconds per sheet. Chemical reactions occur more quickly if heat is applied. The general rule is the reaction occurs about twice as quickly for every 18 degrees Fahrenheit the temperature is raised. (1) Therefore using the forced air heat to warm the printed sheet theoretically accelerated the rate of absorption and oxidation/polymerization.

The final technique chosen was microwave drying. The microwave oven theoretically accelerated the chemical reactions in the same manner as the forced air heat. However, the microwave causes the molecules within a structure to vibrate and to heat from within the sheet instead of heating from the outside. Stacks of 25 sheets were dried for 15 seconds at 130 degrees Fahrenheit in a Sanyo 700 watt microwave oven.

Press Conditions

The Itek 960 Offset Duplicator is a small, sheetfed lithographic press. A simple explanation of the lithographic process follows. Fountain solution and ink are metered onto a plate. Ink adheres to the image area and the fountain solution adheres to the non-image area. The image is transferred to a blanket cylinder and finally printed onto a substrate which is held in place by grippers between the blanket cylinder and the impression cylinder.

A slightly acidic fountain solution was used in this experiment. This was used to simulate typical print shop conditions for offset printing.

The test plate was a 3M Viking negative working aluminum plate. A metal plate was chosen because of the number of impressions (6,400) that were printed. A paper or plastic plate might not have maintained a sharp image as well under these conditions.

Since four inks were tested, four wash-ups and make-readys were needed. A press wash-up occurred after each of the test runs to eliminate the contamination of one ink by another.

Test Equipment

The Kodak Ektaprint 200 copier/duplicator is a commercially produced electrophotographic system that reproduces images by electrically charging a surface, affixing toner to the charged image areas, transferring the image to a substrate and then fusing the toner into place. The Kodak copier uses both heat (340 degrees Fahrenheit) and pressure (18 psi) to fuse the powdered toner of the image area to a sheet of paper.

A subjective visual examination was used to denote obvious cases of unwanted lithographic image transfer. This researcher and the Kodak researchers examined each sheet under graphic arts standard viewing light (5000 Kelvin). The visual test was then quantified by density readings. A Gretag 186 reflection densitometer was used to measure the density of transferred ink on each sheet that had been visually assessed as exhibiting lithographic image transfer.

Density is the light stopping ability of an image or base material and is measured as the logarithm of opacity. Opacity is the reciprocal of reflectance or transmittance. Reflectance, simply stated, is the amount of incident light reflected from a real object's surface and transmittance is the incident light that passes through any given object. The black ink to be used in the test runs absorbed light and therefore had a greater density than the sheet's average, preprinted density.

If a sheet passed the visual test but the density readings were within the error latitude (+ or -.005) of the reflection densitometer, the sample was rejected.

Statistical Analysis

Image transfer for each sample was written as the number of sheets that do not exhibit ink transfer/the number of sheets that do exhibit ink transfer. If a test sample exhibited any ambient ink lithographic transfer, the hypothesis was rejected. These samples are considered unfavorable for imprinting in an Ektaprint 200 copier/

duplicator or similar electrophotographic copiers.

The Wilcoxon sign test is a nonparametric statistic which helps determine if the preferences, that is the likelihood, of occurrence for two items are identical. Nonparametric statistics do not require "assumptions about the form of the population probability distribution." (2) The sign test was chosen to determine if any samples should be excluded from the test population due to the inability to determine preference of occurrence of image transfer.

The hypotheses tested are stated as follows. H_o: No preference for print conditions to affect lithographic image transfer exists. H_1: Preference for print conditions to affect lithographic image transfer exist. The researcher tested the null hypothesis. A .05 level of significance was established. If the null was rejected, then the sample was considered to have a preference for the print conditions to affect lithographic image transfer. To accept the null, a z score had to be within +1.96 and -1.96. Z scores for each samples set were determined.

In addition to the image transfer sign test, descriptive statistics in the scatter diagram format were used to visually compare the results of the ink tack, the percentage of solvent in the ink, and paper moisture content tests. Scatter diagrams are classified as descriptive statistics. The remaining tests results (paper absorptivity, paper pH and paper curl) were listed when appropriate.

<u>Other Tests</u>

All additional tests were performed on unprinted paper samples, or ink samples taken directly from the ink can.

The pH of the paper was tested using TAPPI standard 509. As stated in Chapter Two, many researchers believe that papers with an acidic pH tend to retard the drying of inks. Testing the paper pH before printing indicated whether the paper had an acidic or alkaline pH that might have affected drying.

Ink tack is an important factor in how ink performs on press. Lithographic inks must have a high enough tack to split from the ink train rollers and the blanket cylinder prior to placing a sharp print on the paper's surface. Simultaneously, the tack must be sufficiently low to prevent paper picking, linting, and to allow the ink to solidify properly. Ink tack was tested on a C-46 Inkometer at a speed of 942 feet per minute. Readings were taken at 30 seconds, 70 seconds, 130 seconds and 270 seconds.

The percentage of solvents in an ink is thought to affect ink drying time. The higher the percentage of solvents, the more slowly ink dries. Inks with a lower percentage of solvent burn-off have a higher percentage of ink solids. To determine the solvent burn-off, each sample ink was weighed initially and then at 20 minute intervals when baked in an over at 150 degree Fahrenheit.

The curl in a paper is important to a paper's runnability in an electrophotographic copier. The Kodak curl test and curl measurement chart were used to determine if the paper exhibits an excessive amount of curl. Excessive curl deems a paper undesirable for use in electrophoto- graphic copying. The curl test is a subjective visual assessment of 10 sheets of paper placed between the thumb and forefinger and then measured against the Kodak curl measurement chart.

The moisture content of each paper sample was measured by weighing out eight to ten grams of the stock, exposing the sample to a heating lamp set a six watts, and then recording the weight difference after 60 seconds, 120 seconds and 180 seconds. The initial weight was then subtracted from the final weight measurement. The difference of this calculation was then divided by the original sample weight and multiplied by 100. The results were recorded and presented in a scatter diagram.

Paper absorptivity was measured using test sheets and the K & N absorptivity test. The test papers' gloss was also measured. The glossmeter in the Rochester Institute of Technology's paper laboratory was used.

Papers' wire and felt side smoothnesses were measured on a Sheffield and recorded. The papers' calipers were measured using a machinist's micrometer and were also recorded.

ENDNOTES

CHAPTER FOUR

(1) Graphic Arts Technical Service Report, 1979, no. 7225, p. 2.

(2) David R. Anderson, et al, Statistics: Concepts and Applications, 1986, West Publishing Company, St. Paul, p. 589.

CHAPTER FIVE

RESULTS AND CONCLUSIONS

The purpose of this research was to determine if an image, printed under specified conditions, will not transfer to the next sheet during electrophotographic imprinting. Of the 64 samples tested, 21 paper/ink/drying combinations exhibited no lithographically printed image transfer from the fuser roller of the Ektaprint 200 copier/duplicator to subsequent sheets through the copying train under visual assessment. Forty-one of the test samples were visually assessed as exhibiting varying degrees of image transfer. Two samples demonstrated no preference for print conditions to affect image transfer as determined by the Wilcoxon sign test statistical analysis. These samples were the Xerox XXV Archival Bond paper printed with Van Son CML Oil Base ink and the Gilbert Neu-Tech paper printed with Van Son CML Oil Base ink. Both were dried by enhanced oxidation. Examples of minimal and excessive lithographic ink transfer are included in Appendix C.

General results and conclusions are discussed first, followed by a detailed examination of each of the variables listed in the methodology.

Van Son's Tough Tex ink produced the most consistent results of any variable in the sample set. The Tough Tex ink demonstrated no transfer regardless of paper stock or drying condition. The only exception to this was a two sheet transfer in the rule line image area of the Xerox 4024 stock dried in a microwave oven. While the transfer was visually perceptible under standard lighting conditions, the ink stain was equal to the paper's density.

Conversely, the two quickset inks tended to promote image transfer on most of the paper stocks regardless of drying conditions. The density readings of the ink transfer stains were consistently higher for the quickset inks than for the rubber base ink or the Van Son Tough Tex. Further- more, the quickset inks tended to promote image transfer in all image areas, rules, type, graphic and screen tints.

The Kohl Madden ink stain density readings were slightly lower than those for the Van Son ink. The ink tests indicated that the Kohl Madden ink has a slightly lower percentage of solvents than the Van Son ink. This could account for the lower density readings.

The Van Son Rubber Base Plus ink seemed to retard lithographic image transfer in the 25%, 50% and 75% tints in each of the sample sets. This may indicate that screening rubber base inks could render them suitable for letterheads that will be electrophotographically imprinted.

The Kohl Madden Offset I.T. also tended to prevent lithographic image transfer in the 25%, 50% and 75% tints, although less consistently than the Van Son Rubber Base

Plus. The sample sets which were visually assessed as exhibiting image transfer when printed with the Kohl Madden ink were: Xerox 4024 Dual Purpose dried by oxidation, the Xerox 4024 Dual Purpose, Xerox XXV Archival Bond and Gilbert Neu-Tech dried by microwave. The Hammermill Offset paper consistently demonstrated no visual image transfer in the tints. This may be due to this stock's higher absorptivity.

The enhanced oxidation drying variable produced the second most consistent results. Samples dried by enhanced oxidation were visually assessed as exhibiting no lithographical image transfer on most paper stocks printed with most of the inks. The exceptions were Xerox 4024 Dual Purpose, Xerox XXV Archival Bond and Gilbert Neu-Tech papers printed with Van Son Rubber Base Plus ink. The two samples (Xerox XXV Archival Bond and Gilbert Neu-Tech printed with Van Son CML Oil Base ink) which exhibited no preference for print conditions to affect image transfer were dried by enhanced oxidation.

Enhanced oxidation drying also exhibited no visually perceptible image transfer on any sample in the tint image areas. This may indicate that screening inks to less than 75% may prevent image transfer with similar papers and similar inks when dried for at least seven days.

The printed sheets dried by forced air heat proved unsuitable for use in the Ektaprint 200 copier/duplicator. The heat impinged on the sheets apparently dried them excessively. When the sheets were run through the Ektaprint copier, they wrinkled and tended to stick together. However, ink stain density readings tended to be lower for printed sheets dried by this method than for printed sheets dried by 24 hour oxidation or microwave.

Although sample sets may have exhibited image transfer, the ambient ink film on the fuser roller was easily cleaned. Running a varying number of plain white sheets through the copier removed all ambient lithographic ink from the fuser roller. An excessive build-up of unchecked lithographic ink on the fuser roller could potentially damage the rubber surface of the roller.

Paper

None of the selected paper stocks demonstrated any difficulties on the offset duplicator used to print them. Three of the four paper stocks also ran well through the Ektaprint 200 copier/duplicator. Minor skipping problems were encountered with the Hammermill offset stock during the copier run. However, no paper jams were encountered during any copier run.

The curl of the sample papers was relatively consistent. The Hammermill paper tended to curl more than any of the other stocks although its moisture content was actually lower than the Xerox 4024 Dual Purpose.

Whether or not a sample sheet transferred ink seems to be more a function of the ink used and drying conditions applied than paper stock. While a given paper stock may exhibit no image transfer under one set of ink and drying conditions, the same stock may exhibit image transfer under a different set of ink and drying conditions.

Inks

The inks used were printed in the following order: Van Son Tough Tex, Van Son Rubber Base Plus, Van Son CML Oil Base and Kohl Madden Offset I.T.

The Van Son Tough Tex ink performed well on press despite indications from an ink chemist that it could prove problematic on an offset duplicator. The solid ink densities were consistently high and the ink remained open on the ink train during the 45 minute press run.

The Van Son Rubber Base Plus ran well and produced no unusual effects during the press run.

The Van Son CML Oil Base and Kohl Madden Offset I.T. presented slight emulsification problems. Lower solid ink densities were measured for these inks than the rubber base ink or Tough Tex. The Van Son quick set ink ran at a consistently higher solid ink density than the Kohl Madden ink.

Drying Techniques

Twenty-four hour oxidation appeared to be insufficient to prevent the transfer of a lithographic image during electrophotographic imprinting. Every ink and paper combination, except for paper stocks printed with Tough Tex, exhibited some degree of lithographic image transfer. While the ink might touch dry in this amount of time, apparently polymerization had not yet occurred to a degree that prevents the ink from resoftening.

Allowing sample sets to dry a full seven days before running through an electrophotographic copier dramatically improved the absence of lithographic image transfer. The seven day period may provide ample time for most of the inks tested to resist resoftening. The sole exception was the Van Son Rubber Base Plus. This result is not surprising because the chemistry of a rubber base ink is such that the ink never truly dries; it merely sets. A conclusion that may be drawn from this is inks that set are unsuitable for use in an electrophotographic copier. However, an absorbent stock, such as the Hammermill offset, did prevent the rubber base ink from transferring when dried for seven days.

Forced air heat may have helped to lessen the densities of the ink stains; however, it rendered the paper unsuitable for electrophotographic copying. The sheets were subject to excessive wrinkling when dried under forced air heat.

Samples that were dried by microwave have basically the same ink stain density readings as those dried by 24 hour oxidation. Since the microwave samples were not run through the copier immediately after treatment and were permitted to dry for 24 hours, this led the researcher to conclude that microwave drying had relatively no effect on the sample sets.

Press Conditions

The Itek 960 Offset Duplicator performed well during testing. No unusual problems were encountered. The aluminum plate provided excellent images. It neither scummed nor showed excessive wear.

Test Equipment

The sample sets were run through the Ektaprint 200 copier/duplicator in the following order. All printed sheets dried by microwave, all printed sheets dried by forced air heat and all printed sheets dried by 24 hour oxidation were run on Saturday, April 23, 1988 a full 24 hours after the press runs were completed. All printed sheets dried by seven day oxidation were run through the Ektaprint 200 on Friday, April 29th, 1988.

The Ektaprint 200 copier/duplicator maintained a consistent fusing temperature of 340 degrees Fahrenheit throughout the run. The temperature was checked periodically with a temperature gun. The fusing roller pressure was set at 18 psi.

During the April 23rd copier run, the cleaning wick of the Ektaprint began plugging up. Black bands became noticeable on the fuser rollers. A sufficient number of clean-up sheets larger than the test form were run through the copier to alleviate this problem. The researchers carefully monitored the wick and the fuser rollers to ensure that wick or roller build-up would not be accredited as lithographic image transfer.

Statistical Analysis

The Wilcoxon sign test determined that two of the 64 samples exhibited no preference for print conditions to affect lithographic image transfer. Those samples were Xerox XXV Archival Bond and Gilbert Neu-Tech printed with Van Son CML Oil Base ink and dried by enhanced oxidation. The z score for the Xerox XXV sample set was +1.09. The z score for the Gilbert Neu-Tech sample set was -0.73. Any z score within +1.96 and -1.96 satisfied the .05 level of significance. Table 6 (Appendix E) contains z scores for each of the sample sets.

Other Tests

The researcher measured ink tack on a C-46 Inkometer in the Rochester Institute of Technology's Ink Testing Laboratory. Readings were taken at 30 seconds, 70 seconds, 130 seconds and 270 seconds. Results appear in Table 1. The

Kohl Madden ink had the highest tack reading, followed by Tough Tex, Van Son Rubber Base Plus and CML Oil Base. None of the inks caused picking or linting on press and the image areas were generally sharp. Therefore the researcher concluded that the ink tacks were acceptable for this type of press run under the stated conditions. The scatter diagrams appear in Figures 2 through 5, Appendix D.

INK TACK

Van Son Rubber Base Plus	**Tack**
after 30 seconds	10.4
after 70 seconds	11.0
after 130 seconds	11.2
after 270 seconds	11.4
Van Son Tough Tex	**Tack**
after 30 seconds	12.2
after 70 seconds	12.0
after 130 seconds	11.8
after 270 seconds	11.4
Van Son CML Oil Base	**Tack**
after 30 seconds	9.8
after 70 seconds	9.4
after 130 seconds	9.4
after 270 seconds	9.2
Kohl Madden Offset I.T.	**Tack**
after 30 seconds	12.0
after 70 seconds	12.0
after 130 seconds	12.4
after 270 seconds	12.8

Table 1. Ink tack measurements taken from a C-46 Inkometer.

The amount of solvent in an ink can affect the rate at which that ink dries. To determine solvent percentage, each of the ink samples in the experiment was heated in an oven at 150 degrees Fahrenheit for one hour. The weight of each test ink was monitored every 20 minutes. Results are listed in Table 2.

INK SOLVENT WEIGHT

Van Son Rubber Base Plus	**Weight**
initial weight	5.1 grams
after 20 mins.	4.5 grams
after 40 mins.	3.1 grams
after 60 mins.	2.4 grams
overall change	2.7 grams

Van Son Tough Tex	**Weight**
initial weight	5.1 grams
after 20 mins.	3.5 grams
after 40 mins.	3.2 grams
after 60 mins.	3.1 grams
overall change	2.0 grams

Van Son CML Oil Base	**Weight**
initial weight	5.0 grams
after 20 mins.	4.6 grams
after 40 mins.	2.9 grams
after 60 mins.	2.3 grams
overall change	2.7 grams

Kohl Madden Offset I.T.	**Weight**
initial weight	5.4 grams
after 20 mins.	4.7 grams
after 40 mins.	3.5 grams
after 60 mins.	2.5 grams
overall change	2.9 grams

Table 2. Test results from burning off the solvents in each of the sample inks.

Three of the four inks tested underwent an equivalent overall change in weight. The exception was Van Son's Tough Tex. According to an ink chemist, Tough Tex contains a high percentage of solids and would therefore change less than the other inks. The high solids' percentage may contribute to the tendency of Tough Tex ink to prevent lithographic image transfer in electrophotographic copiers.

Scatter diagrams for each of the test inks appear in Figures 6 through 9, Appendix D.

Paper moisture content affects both ink drying and runnability in the electrophotographic equipment. Each of the papers in the sample sets was tested for moisture content. The results appear in Table 3. Scatter diagrams for each of the test papers appear in Figures 10 through 13, Appendix D.

PAPER SAMPLES' MOISTURE CONTENT

Xerox 4024 Dual Purpose	**Weight**
initial weight	8.94 grams
weight after 60 secs.	8.73 grams
weight after 120 secs.	8.64 grams
weight after 180 secs.	8.61 grams
overall change	.33 grams
Moisture content	3.69%

Xerox XXV Archival Bond	**Weight**
initial weight	8.68 grams
weight after 60 secs.	8.64 grams
weight after 120 secs.	8.58 grams
weight after 180 secs.	8.44 grams
overall change	.24 grams
Moisture content	2.76%

Gilbert Neu-Tech	**Weight**
initial weight	9.20 grams
weight after 60 secs.	9.11 grams
weight after 120 secs.	9.01 grams
weight after 180 secs.	8.88 grams
overall change	.32 grams
Moisture content	3.48%

Hammermill Offset	**Weight**
initial weight	9.11 grams
weight after 60 secs.	9.06 grams
weight after 120 secs.	8.86 grams
weight after 180 secs.	8.79 grams
overall change	.32 grams
Moisture content	3.51%

Table 3. Moisture content test results for each paper sample.

Each of the test papers had approximately the same moisture content. Even the Hammermill Offset proved to have a lower than predicted moisture content. The low moisture content of each test paper probably accounted for the ease of three of the four sample sets copier runs. The only time copying proved problematic was when the forced air heat set was run. The forced air heat seemed to lower the moisture content to an unacceptable level. Samples dried by forced air heat were subject to wrinkles and skipping problems when run through the Ektaprint 200 copier/duplicator.

The K&N absorptivity test was used to measure the percentage of absorptivity of each test sheet. Table 7, Appendix E contains the data used to determine the rankings listed in Table 4.

% Absorptivity
1) 77.14, Neu-Tech
2) 85.12, Xerox Bond
3) 89.11, Xerox 4024
4) 89.78, Hammermill

Table 4. Paper abosorptivity percentages as determined by the K&N absorptivity test.

The paper's percent absorptivity did not appear to have a noticeable effect on the presence or absence of image transfer. The instances of image transfer were relatively consistent for sample stocks printed with a given ink and dried under a given condition.

Paper pH was tested using TAPPI standard 509. The Xerox 4024 Dual Purpose, and the Xerox XXV Archival Bond were found to have relatively neutral pH; 6.9 and 7.1 respectively. The Gilbert Neu-Tech was found to have a slightly alkaline pH of 7.6. The Hammermill Offset was found to have a slightly acidic pH of 6.7.

It was noted in Chapter Two that papers having an acidic pH may affect ink drying characteristics. In this study those papers did not seem to produce perceptible lithographic image transfer. The type of ink and/or the drying conditions were more likely to produce visible ink stains on the test papers.

The paper curl was tested after each sample set ran through the Ektaprint copier. Table 8 lists the data from this test. There was no standard to determine an unacceptable amount of curl. However, the more a paper curled, the greater the likelihood of occurance of copier-related malfunctions.

No paper variable produced an excessive amount of curl, except for the sample sets that were dried by forced air heat. Paper stocks dried by this method had curl as high as 11. The other three samples had paper curl measures of two to seven, while the samples dried by forced air heat exhibited curls anywhere from seven to 11. Most curl measured for the forced air heat sample were ten.

The high curl papers not only caused copier-related malfunctions such as paper jams in the paper carrying train, but also in this study, the papers with high curl were also the papers most likely to wrinkle in the copying process.

CHAPTER SIX

RECOMMENDATIONS

This pilot study isolated 21 samples that prevented the transfer of lithographic ink images in electrophotographic imprinting for the given test conditions. This research also discovered 41 print conditions that are unsuitable, allowing such transfer. The use of Tough Tex ink during the lithographic print run seems to help prevent the transfer of lithographic image during electrophotographic imprinting. Seven day oxidation also acts as a positive variable in the prevention of lithographic image transfer. Screening lithographic inks to less than 100%, as this researcher did in the tone bars of the test form, also seems to retard lithographic image transfer under certain circumstances.

The study also identified several ink and paper characteristics that could be studied in greater depth. This is because the researcher only identified the variable characteristics, and did not analyze the variance between them.

Some questions for future researchers to investigate follow. Can lithographic inks be modified to promote a faster polymerization rate? Is there a linear relationship between the solvent content of a lithographic ink and its tendency to transfer during electrophotographic imprinting?

If the fuser temperature ofan electrophotographic copier is higher than 340 degrees Fahrenheit will the "no transfer" samples in this study exhibit lithographic ink transfer? Do letterheads run through laser printers exhibit lithographic image transfer? Does the finish of the paper surface affect lithographic image transfer? Does the hue of the ink affect lithographic image transfer? The list may be endless.

Ink/paper/drying interactions are complex. This study merely isolated a few conditions that seem to prevent lithographic images from transferring in an Ektaprint copier. While these results may be useful to future graphic arts researchers interested in research of this nature, it cannot be used to draw conclusions about stationery printed, or electrophotographically imprinted under different conditions.

APPENDIX A

A graphical representation of the three factor, four level factorial experimental design used in determining whether or not print conditions affect the likelihood of lithographic ink transfer.

	Van Son Rubber	Van Son Tough Tex	Van Son CML Oil	Kohl Madden Offset I.T.
24 hour oxidation				
Xerox 4024				
Xerox Bond				
Neu-Tech				
Hammermill				
Enhanced oxidation				
Xerox 4024				
Xerox Bond				
Neu-Tech				
Hammermill				
Forced air heat				
Xerox 4024				
Xerox Bond				
Neu-Tech				
Hammermill				
Microwave heating				
Xerox 4024				
Xerox Bond				
Neu-Tech				
Hammermill				

APPENDIX B

A printed example of the test form from the Gilbert Neu-Tech, Van Son Tough Tex, 24 hour oxidation print run.

BRAND X INC.

National Headquarters
2735 Washington Boulevard
Center City, New York 12315
(915) 897-7735

APPENDIX C

Example of minimal ink transfer from the Xerox 4024, Van Son Rubber Base Plus, 24 hour oxidation test run and an example of excessive ink transfer from the Xerox 4024, Van Son CML Oil Base, 24 hour oxidation test run.

BRAND X INC.

National Headquarters
2735 Washington Boulevard
Center City, New York 12315
(915) 897-7735

20 April 1988

Mrs. Janice Fellows
1234 Jackson Blvd.
Yourtown, NY 14458

Dear Mrs. Fellows,

Brand X Inc. would like to invite you and your family to participate in a nationwide market study of our new product, the SuperMop.

SuperMop is a revolutionary new twist on the traditional mop we all know and love. Brand X Inc. is convinced you'll agree with us, SuperMop will change the way you do housework.

If you choose to participate in our study, please fill-in the enclosed form and return it to us, postage free.

Sincerely,

Mr. X. Axis
President, Brand X, Inc.

BRAND X INC.

National Headquarters
2735 Washington Boulevard
Center City, New York 12315
(915) 897-7735

20 April 1988

Mrs. Janice Fellows
1234 Jackson Blvd.
Yourtown, NY 14458

Dear Mrs. Fellows,

Brand X Inc. would like to invite you and your family to participate in a nationwide market study of our new product, the SuperMop.

SuperMop is a revolutionary new twist on the traditional mop we all know and love. Brand X Inc. is convinced you'll agree with us, SuperMop will change the way you do housework.

If you choose to participate in our study, please fill-in the enclosed form and return it to us, postage free.

Sincerely,

Mr. X. Axis
President, Brand X, Inc.

APPENDIX D

GRAPHS

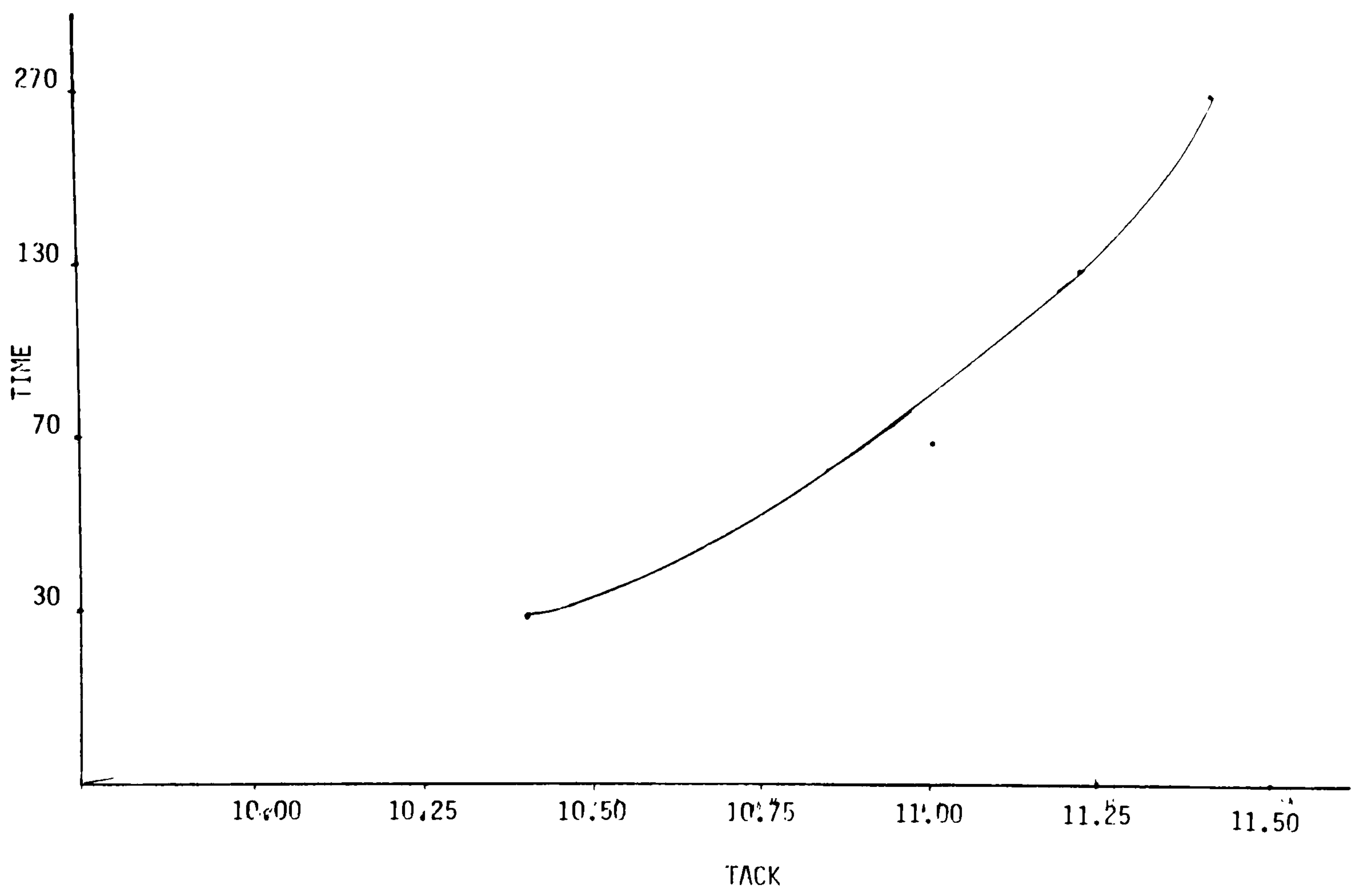

Figure 2. Graph depicting ink tack change over time for Van Son Rubber Base Plus

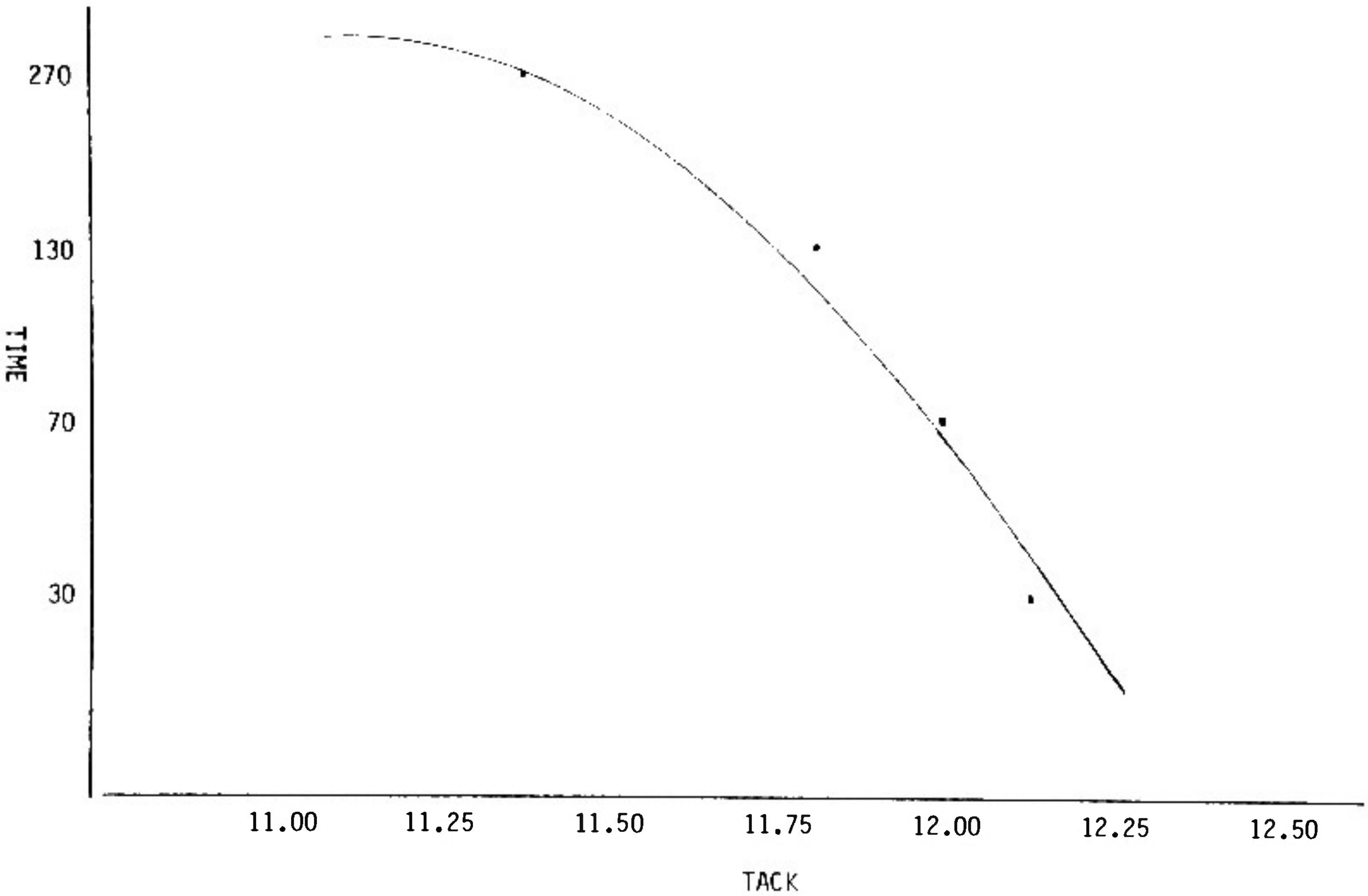

Figure 3. Graph depicting ink tack change over time for Van Son Tough Tex

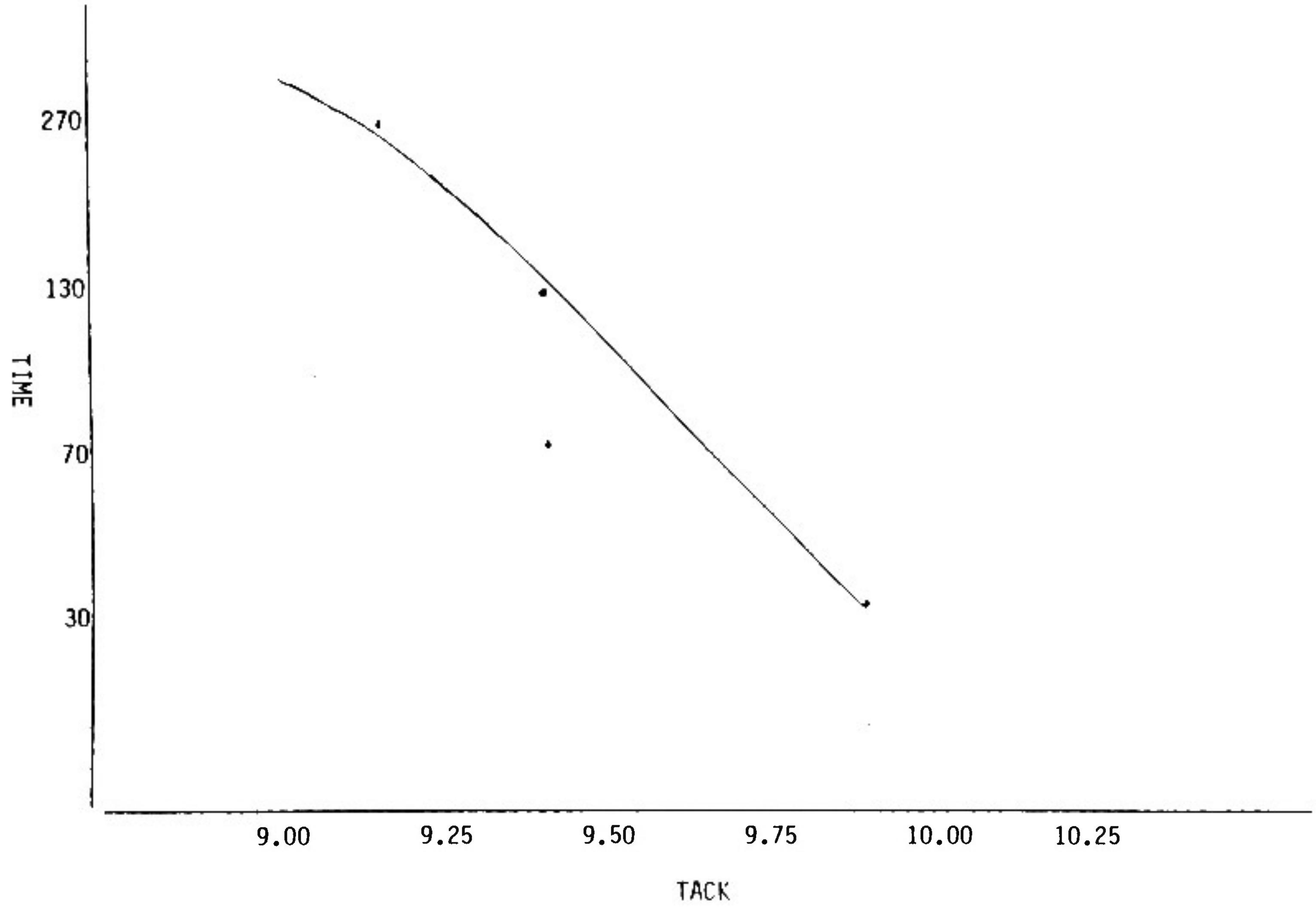

Figure 4. Graph depicting ink tack change over time for Van Son CML Oil Base

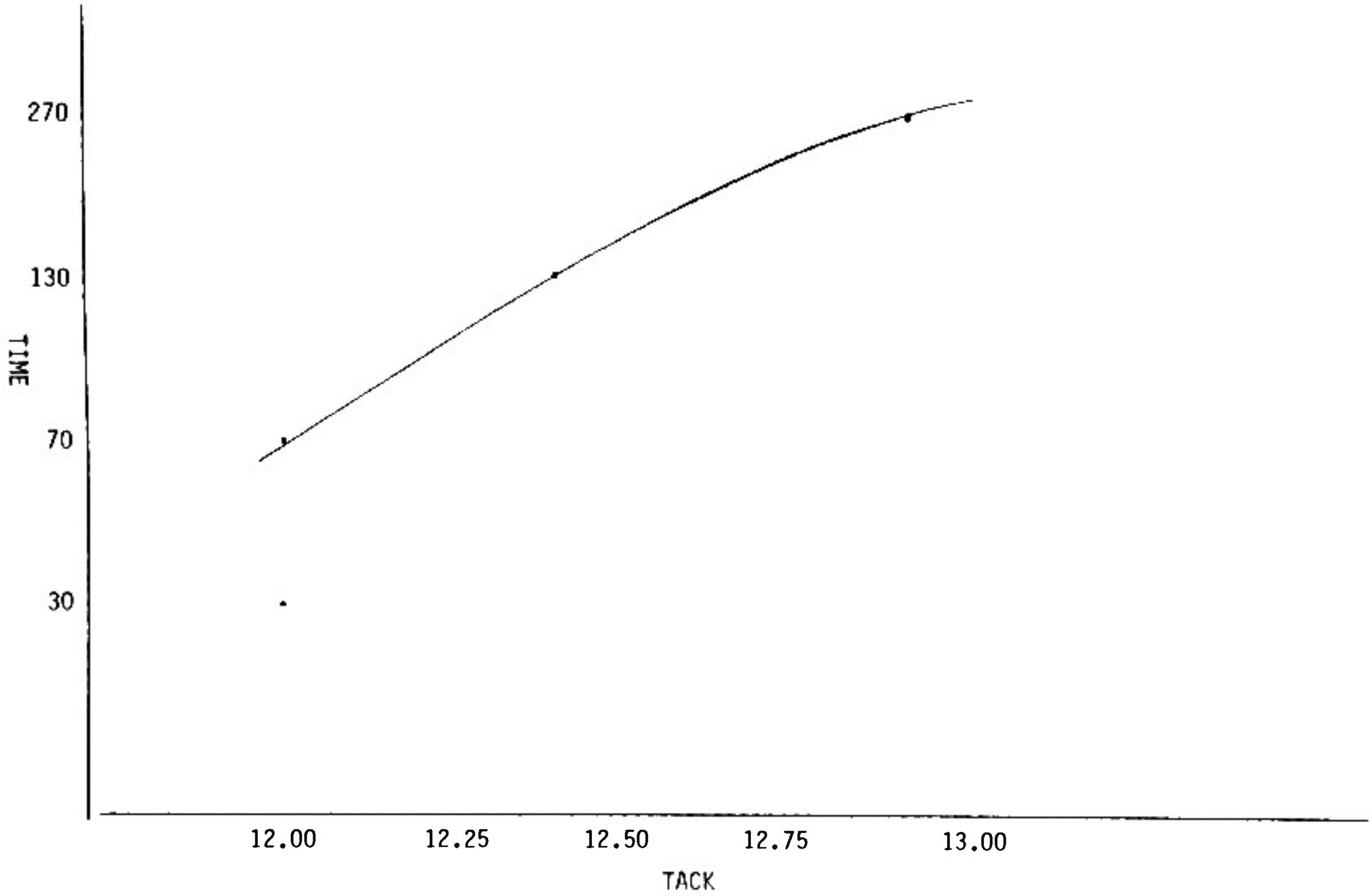

Figure 5. Graph depicting ink tack change over time for Kohl Madden Offset I.T.

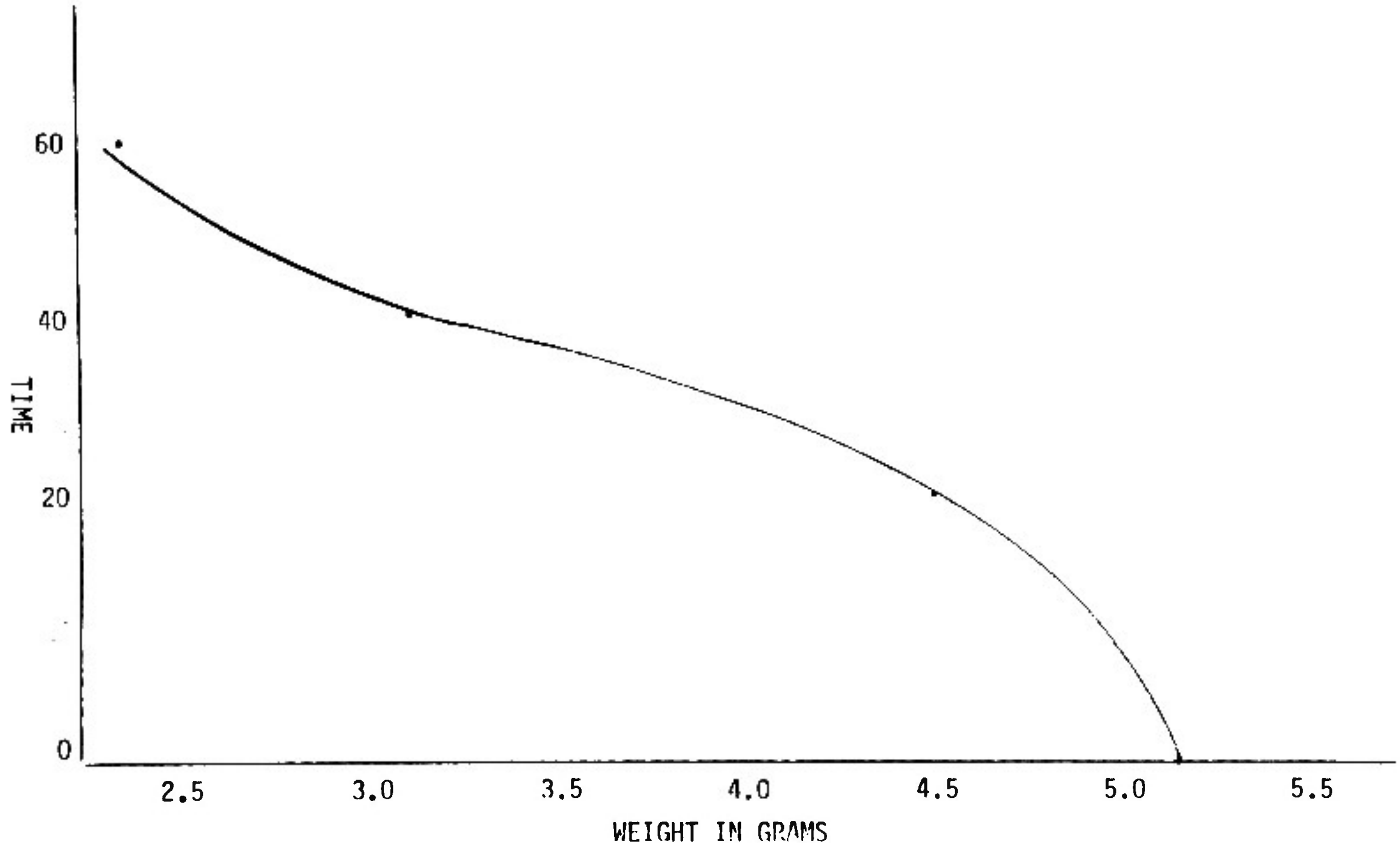

Figure 6. Graph depicting amount of solvents burned off over time for Van Son Rubber Base Plus

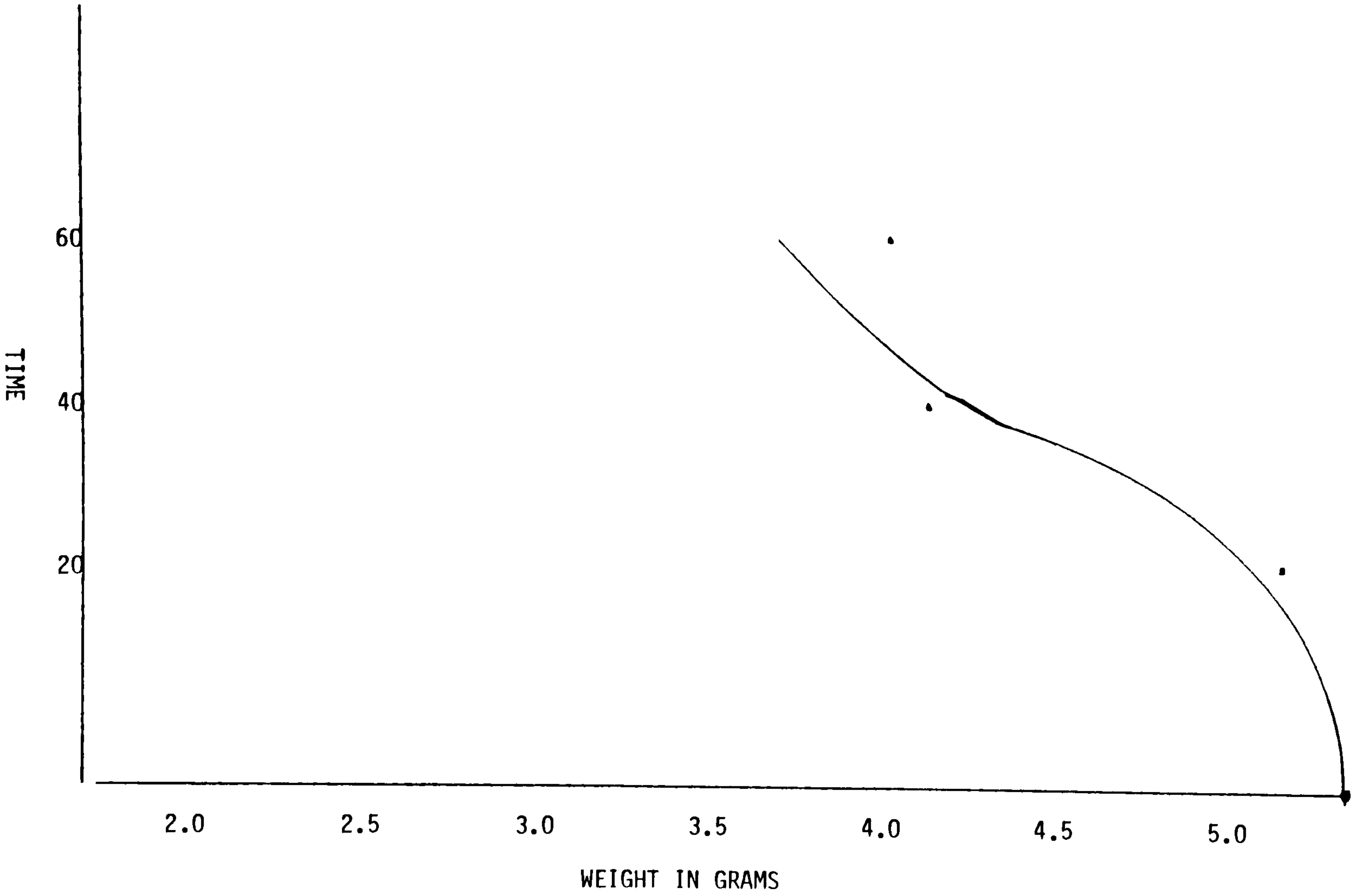

Figure 7. Graph depicting amount of solvents burned off over time for Van Son Tough Tex

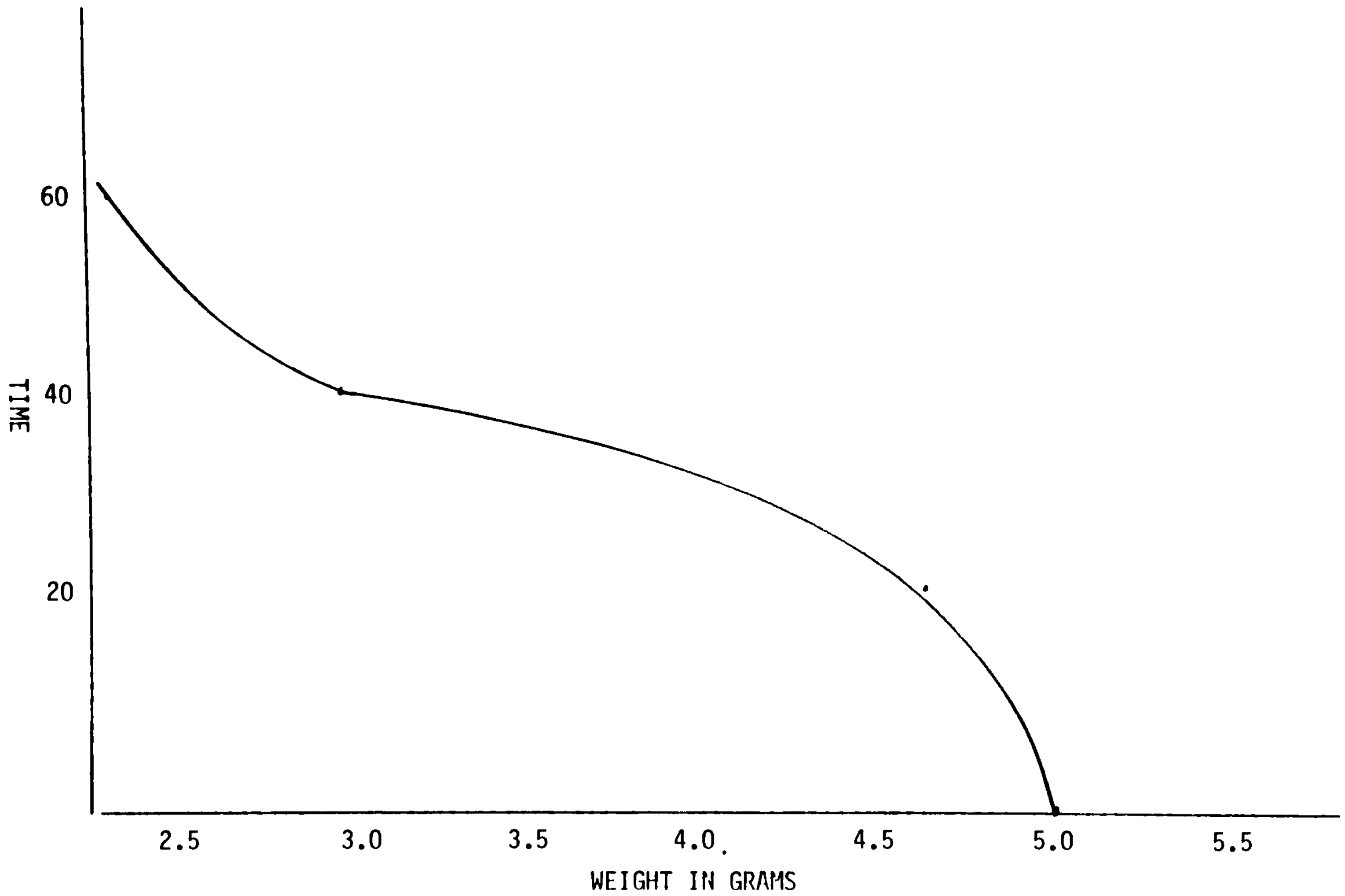

Figure 8. Graph depicting amount of solvents burned off over time for Van Son CML Oil Base

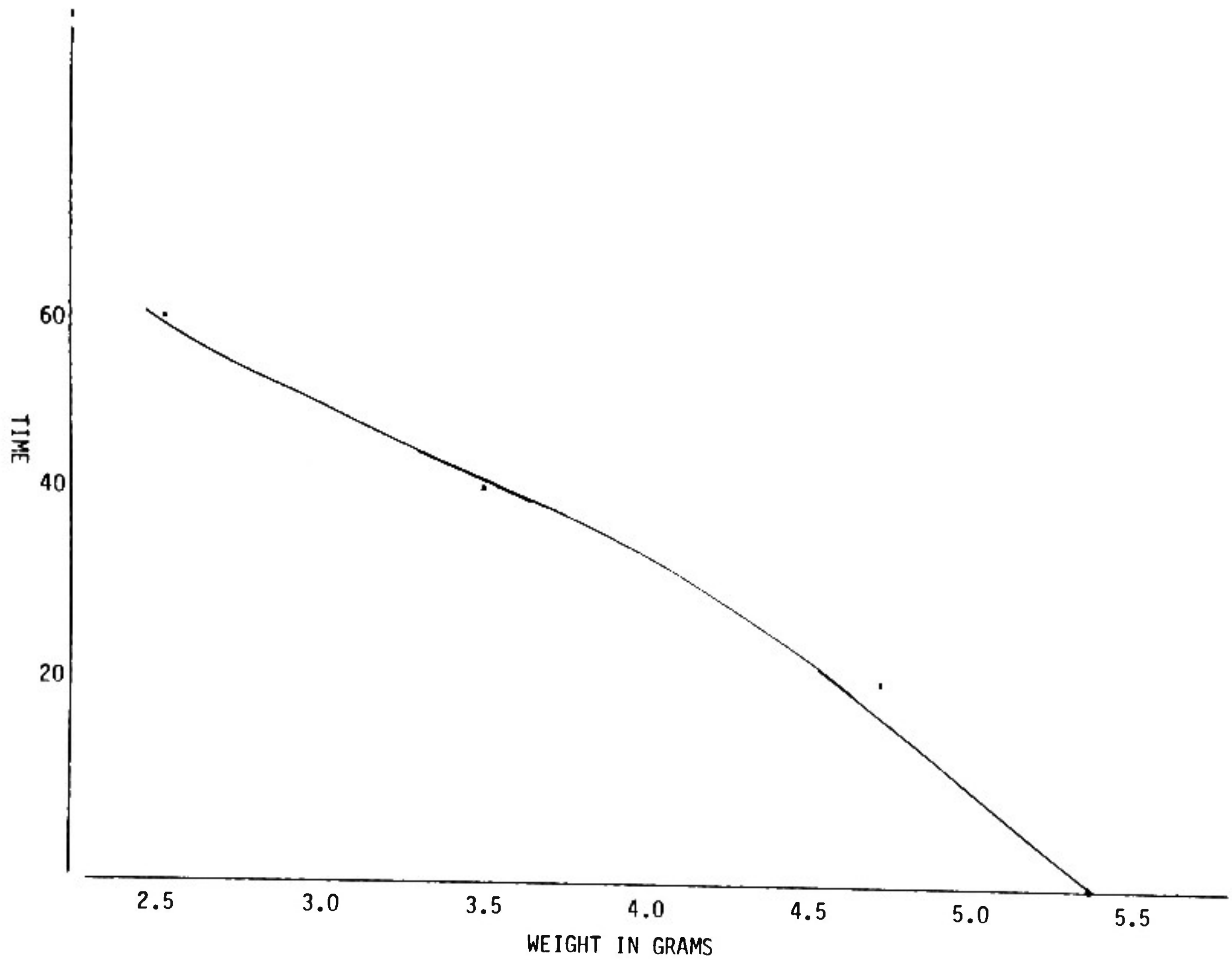

Figure 9. Graph depicting amount of solvents burned off over time for Kohl Madden Offset I.T.

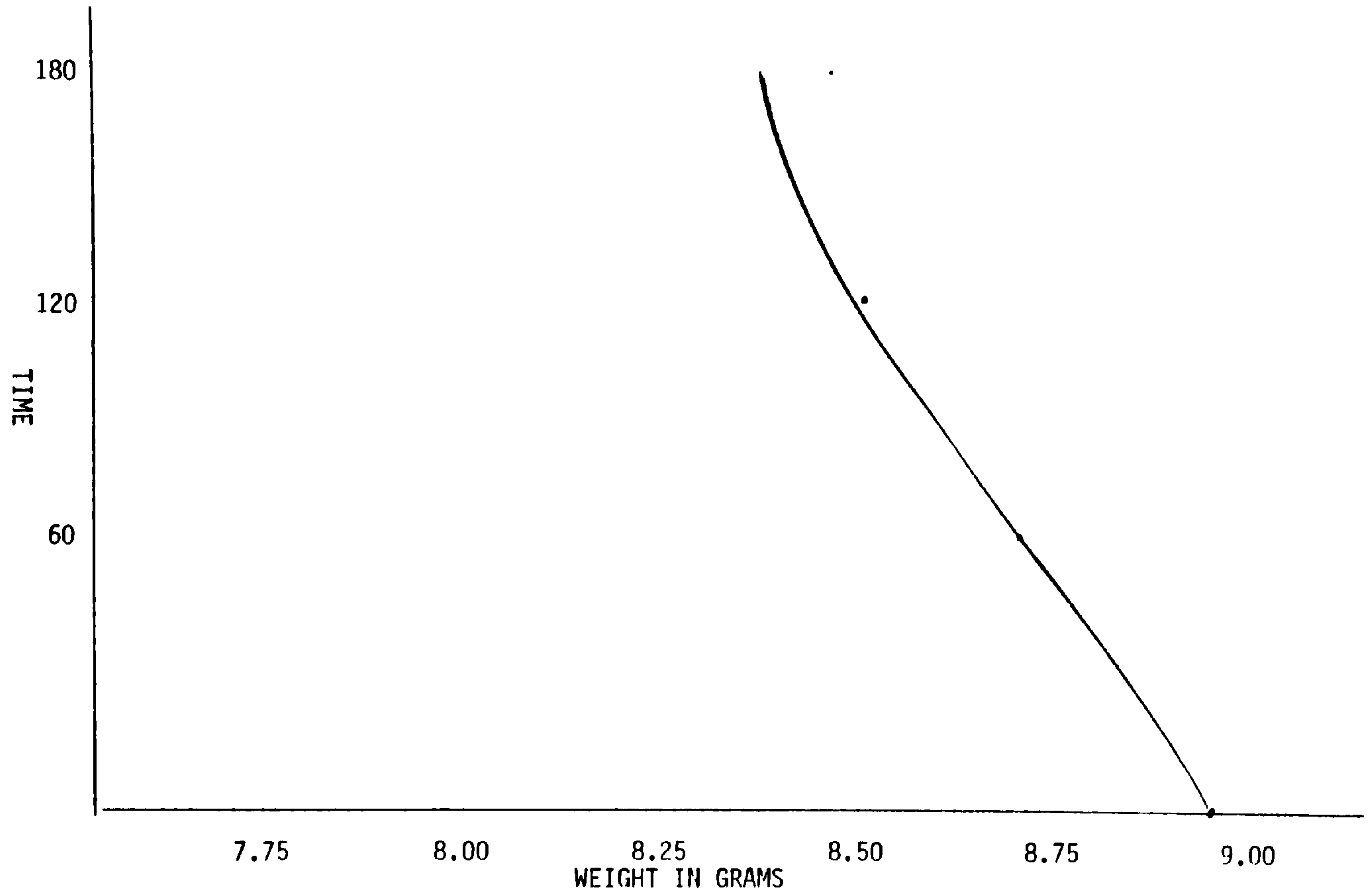

Figure 10. Graph depicting amount of moisture content over time for Xerox 4024 Dual Purpose

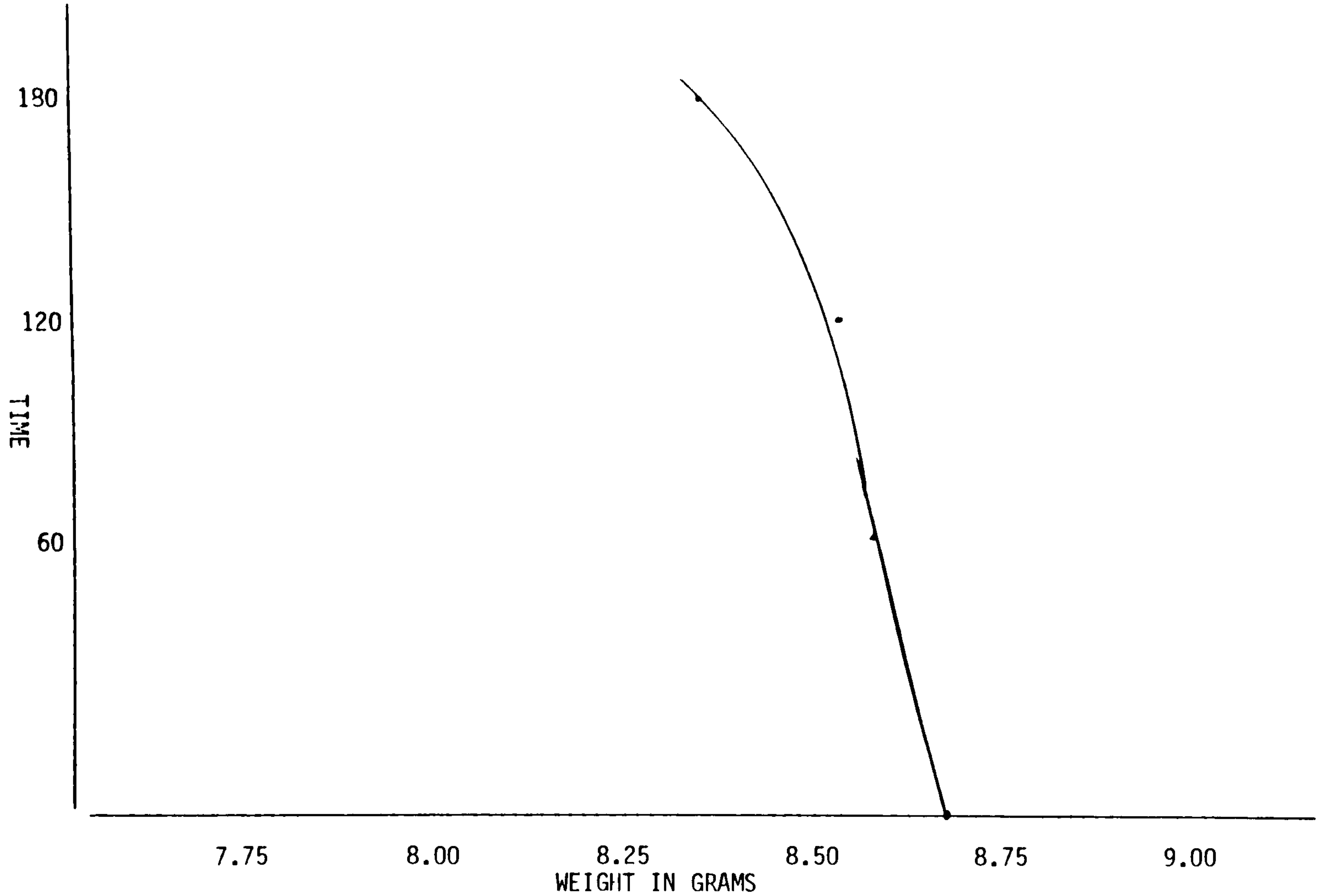

Figure 11. Graph depicting amount of moisture content over time for Xerox XXV Archival Bond

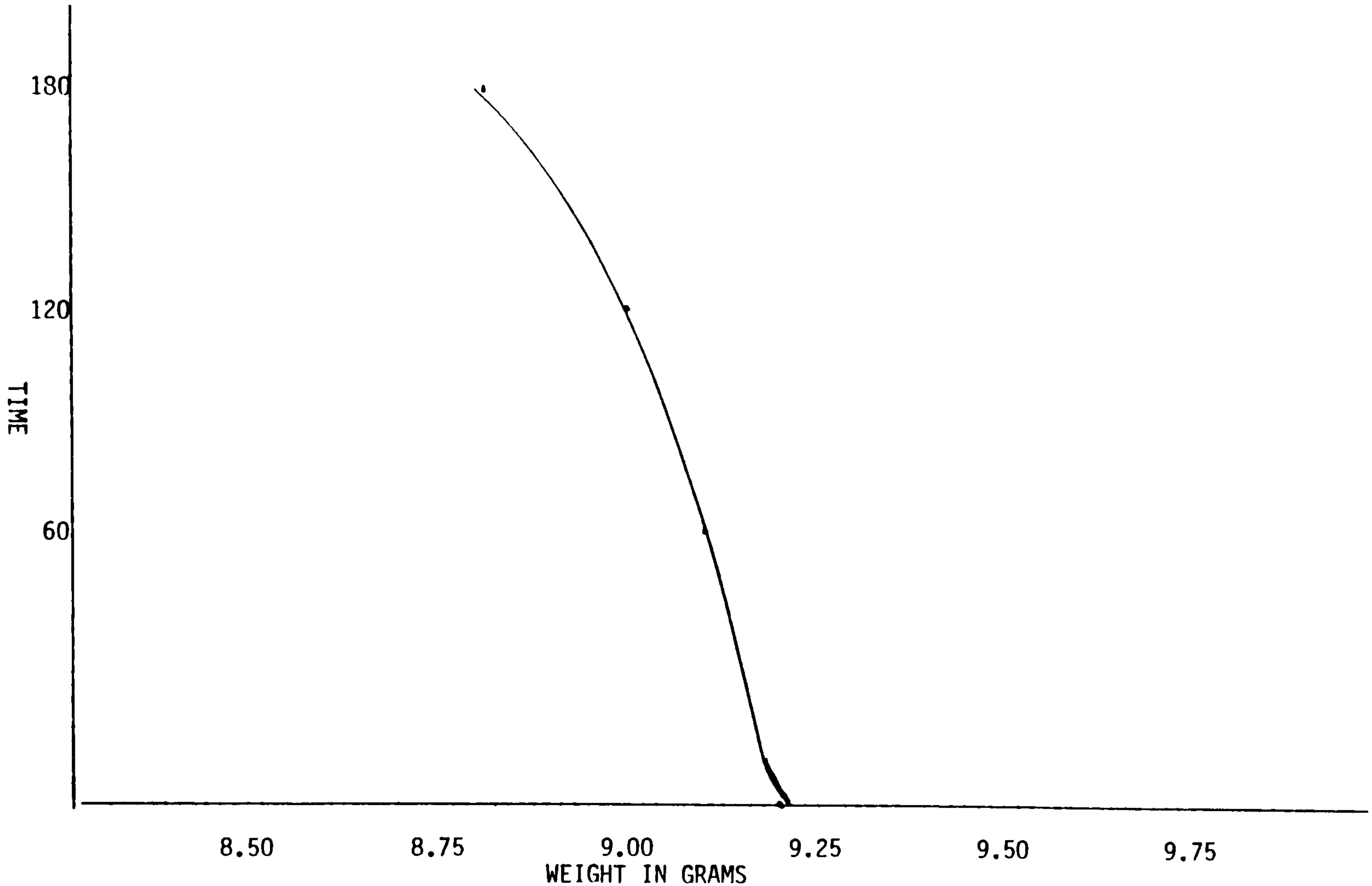

Figure 12. Graph depicting moisture content over time for Gilbert Neu-Tech

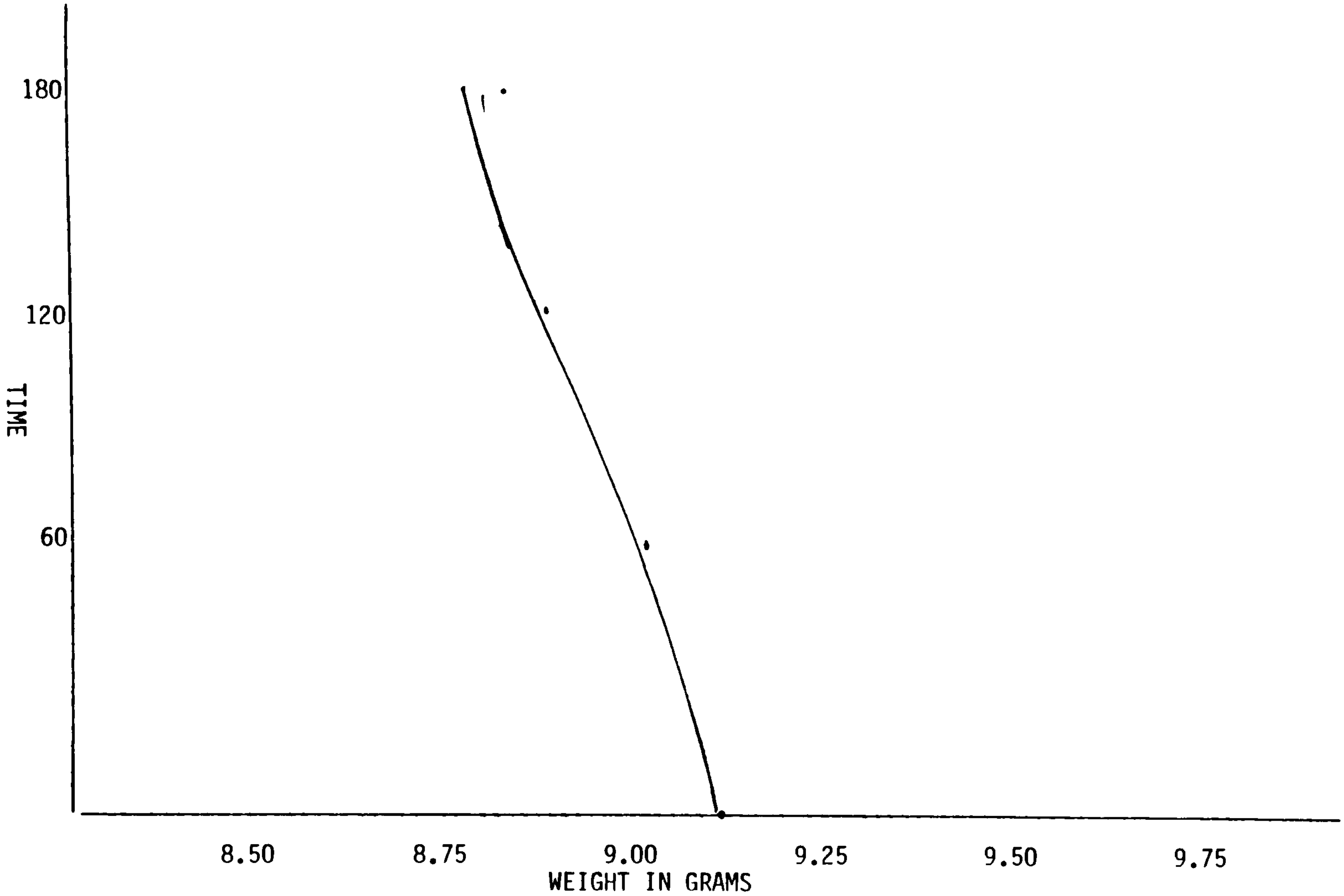

Figure 13. Graph depicting amount of moisture content over time for Hammermill Offset

APPENDIX E

TABLES

Table 5. Lithographic image transfer data. Expressed as the number of sheets that exhibited lithographic image transfer during electrophotographic imprinting/the number of sheets that did not exhibit lithographic image transfer for each of the test samples.

DRYING CONDITION: 24 Hour Oxidation

Paper Stock: Xerox 4024

Rubber Base Plus	5/25
Van Son Tough Tex	30/0
Van Son CML Oil Base	1/29
Kohl Madden Offset I.T.	1/29

Paper Stock: Xerox Archival Bond XXV

Rubber Base Plus	4/26
Van Son Tough Tex	30/0
Van Son CML Oil Base	2/28
Kohl Madden Offset I.T.	3/27

Paper Stock: Gilbert Neu-Tech

Rubber Base Plus	5/25
Van Son Tough Tex	30/0
Van Son CML Oil Base	2/28
Kohl Madden Offset I.T.	2/28

Paper Stock: Hammermill Offset

Rubber Base Plus	4/26
Van Son Tough Tex	30/0
Van Son CML Oil Base	2/28
Kohl Madden Offset I.T.	2/28

DRYING CONDITION: Enhanced Oxidation

Paper Stock: Xerox 4024

Rubber Base Plus	8/22
Van Son Tough Tex	30/0
Van Son CML Oil Base	30/0
Kohl Madden Offset I.T.	30/0

Paper Stock: Xerox Archival Bond XXV

Rubber Base Plus	1/29
Van Son Tough Tex	30/0
Van Son CML Oil Base	18/12
Kohl Madden Offset I.T.	30/0

Paper Stock: Gilbert Neu-Tech

Rubber Base Plus	23/7
Van Son Tough Tex	30/0
Van Son CML Oil Base	13/17
Kohl Madden Offset I.T.	30/0

Paper Stock: Hammermill Offset

Rubber Base Plus	30/0
Van Son Tough Tex	30/0
Van Son CML Oil Base	2/28
Kohl Madden Offset I.T.	30/0

DRYING TECHNIQUE: Forced Air Heat

Paper Stock: Xerox 4024

Rubber Base Plus	7/23
Van Son Tough Tex	30/0
Van Son CML Oil Base	2/28
Kohl Madden Offset I.T.	2/28

Paper Stock: Xerox Archival Bond XXV

Rubber Base Plus	5/25
Van Son Tough Tex	30/0
Van Son CML Oil Base	1/29
Kohl Madden Offset I.T.	7/23

Paper Stock: Gilbert Neu-Tech

Rubber Base Plus	6/24
Van Son Tough Tex	30/0
Van Son CML Oil Base	2/28
Kohl Madden Offset I.T.	2/28

Paper Stock: Hammermill Offset

Rubber Base Plus	3/27
Van Son Tough Tex	30/0
Van Son CML Oil Base	3/27
Kohl Madden Offset I.T.	4/26

DRYING TECHNIQUE: Microwave

Paper Stock: Xerox 4024

Rubber Base Plus	3/27
Van Son Tough Tex	28/2
Van Son CML Oil Base	1/29
Kohl Madden Offset I.T.	1/29

Paper Stock: Xerox Archival Bond XXV

Rubber Base Plus	3/27
Van Son Tough Tex	30/0
Van Son CML Oil Base	3/27
Kohl Madden Offset I.T.	2/28

Paper Stock: Gilbert Neu-Tech

Rubber Base Plus	2/28
Van Son Tough Tex	30/0
Van Son CML Oil Base	2/28
Kohl Madden Offset I.T.	2/28

Paper Stock: Hammermill Offset

Rubber Base Plus	2/28
Van Son Tough Tex	30/0
Van Son CML Oil Base	2/28
Kohl Madden Offset I.T.	4/26

Table 6. Z scores for each test sample from the Wilcoxon sign test. A z score within the parameters of +1.96 and -1.96 satisfies the .05 level of confidence.

DRYING CONDITION: 24 Hour Oxidation

Paper Stock: Xerox 4024

Rubber Base Plus	-3.65
Van Son Tough Tex	+5.47
Van Son CML Oil Base	-5.11
Kohl Madden Offset I.T.	-5.11

Paper Stock: Xerox Archival Bond XXV

Rubber Base Plus	-4.01
Van Son Tough Tex	+5.47
Van Son CML Oil Base	-4.74
Kohl Madden Offset I.T.	-4.38

Paper Stock: Gilbert Neu-Tech

Rubber Base Plus	-3.65
Van Son Tough Tex	+5.47
Van Son CML Oil Base	-4.74
Kohl Madden Offset I.T.	-4.74

Paper Stock: Hammermill Offset

Rubber Base Plus	-4.01
Van Son Tough Tex	+5.47
Van Son CML Oil Base	-4.74
Kohl Madden Offset I.T.	-4.74

DRYING CONDITION: Enhanced Oxidation

Paper Stock: Xerox 4024

Rubber Base Plus	-2.55
Van Son Tough Tex	+5.47
Van Son CML Oil Base	+5.47
Kohl Madden Offset I.T.	+5.47

Paper Stock: Xerox Archival Bond XXV

Rubber Base Plus	-5.11
Van Son Tough Tex	+5.47
Van Son CML Oil Base	+1.09*
Kohl Madden Offset I.T.	+5.47

Paper Stock: Gilbert Neu-Tech

Rubber Base Plus	+2.92
Van Son Tough Tex	+5.47
Van Son CML Oil Base	-0.73*
Kohl Madden Offset I.T.	+5.47

*indicates that the null hypothesis was rejected

Paper Stock: Hammermill Offset

Rubber Base Plus	+5.47
Van Son Tough Tex	+5.47
Van Son CML Oil Base	-4.78
Kohl Madden Offset I.T.	+5.47

DRYING TECHNIQUE: Forced Air Heat

Paper Stock: Xerox 4024

Rubber Base Plus	-2.92
Van Son Tough Tex	+5.47
Van Son CML Oil Base	-4.74
Kohl Madden Offset I.T.	-4.74

Paper Stock: Xerox Archival Bond XXV

Rubber Base Plus	-3.65
Van Son Tough Tex	+5.47
Van Son CML Oil Base	-5.11
Kohl Madden Offset I.T.	-2.92

Paper Stock: Gilbert Neu-Tech

Rubber Base Plus	-3.28
Van Son Tough Tex	+5.47
Van Son CML Oil Base	-4.74
Kohl Madden Offset I.T.	-4.74

Paper Stock: Hammermill Offset

Rubber Base Plus	-4.38
Van Son Tough Tex	+5.47
Van Son CML Oil Base	-4.38
Kohl Madden Offset I.T.	-4.01

DRYING TECHNIQUE: Microwave

Paper Stock: Xerox 4024

Rubber Base Plus	-4.38
Van Son Tough Tex	+4.74
Van Son CML Oil Base	-5.11
Kohl Madden Offset I.T.	-5.11

Paper Stock: Xerox Archival Bond XXV

Rubber Base Plus	-4.38
Van Son Tough Tex	+5.47
Van Son CML Oil Base	-4.38
Kohl Madden Offset I.T.	-4.74

Paper Stock: Gilbert Neu-Tech

Rubber Base Plus	-4.74
Van Son Tough Tex	+5.47
Van Son CML Oil Base	-4.74
Kohl Madden Offset I.T.	-4.74

Paper Stock: Hammermill Offset

Rubber Base Plus	-4.74
Van Son Tough Tex	+5.47
Van Son CML Oil Base	-4.74
Kohl Madden Offset I.T.	-4.01

Table 7. Data used to determine percentage absorptivity for each of the test paper samples.

Paper Stock	Density	% Reflectance	% Absorptivity	% Gloss
Xerox 4024	.48	33	89.11	8.7
Xerox Bond	.44	36	85.12	7.3
Neu-Tech	.38	42	77.14	6.5
Hammermill	.49	32.5	89.78	7.6

Table 8. Paper curl data determined for each of the test sample sets.

	Van Son Rubber	Van Son Tough Tex	Van Son CML Oil	Kohl Madden Offset I.T.
DRYING:				
24 hour oxidation				
Xerox 4024	3	3	3	2
Xerox Bond	3	6	6	4
Neu-Tech	3	3	3	4
Hammermill	3	6	3	4
Enhanced oxidation				
Xerox 4024	2	2	2	2
Xerox Bond	6	4	5	5
Neu-Tech	8	4	3	4
Hammermill	5	6	4	6
Forced air heat				
Xerox 4024	5	10	9	7
Xerox Bond	10	10	11	10
Neu-Tech	11	11	11	10
Hammermill	7	9	7	11
Microwave heating				
Xerox 4024	4	4	4	3
Xerox Bond	3	3	3	3
Neu-Tech	3	4	4	4
Hammermill	7	4	7	5

Table 9. Density readings for all samples dried by 24 hour oxidation.

	Paper	SID	Rules	Type	Image	Tones
Xerox 4024						
Rubber Base Plus	.05	1.46	.06-.09	.05-.06	.05-.07	---
V.S. Tough Tex	.05	1.84	---	---	---	---
V.S. CML Oil Base	.05	1.66	.09-.17	.07-.11	.07-.09	.07-.11
Kohl Madden Offset	.05	1.47	.09-.13	.12-.18	.09-.10	.07-.10
Xerox Bond						
Rubber Base Plus	.02	1.38	.03-.05	.02-.04	.02-.05	---
V.S. Tough Tex	.02	1.80	---	---	---	---
V.S. CML Oil Base	.02	1.63	.13-.24	.05-.05	.05-.09	.04-.07
Kohl Madden Offset	.02	1.38	.07-.18	.03-.08	.04-.06	---
Gilbert Neu-Tech						
Rubber Base Plus	.02	1.42	.03-.05	.02-.05	.03-.04	---
V.S. Tough Tex	.02	1.77	---	---	---	---
V.S. CML Oil Base	.02	1.69	.05-.11	.04-.06	.05-.13	.05-.11
Kohl Madden Offset	.02	1.46	.04-.10	.03-.06	.03-.07	---
Hammermill Offset						
Rubber Base Plus.	.03	1.56	.03	.03	---	---
V.S. Tough Tex	.03	1.70	---	---	---	---
V.S. CML Oil Base	.03	1.44	.05-.12	.04-.07	.05-.08	.04-.06
Kohl Madden Offset	.03	1.67	.04-.07	.04-.06	.04-.05	---

Table 10. Density readings for all samples dried by enhanced oxidation (seven days).

	Paper	SID	Rules	Type	Image	Tones
Xerox 4024						
Rubber Base Plus	.05	1.50	.05-.07	---	.05-.07	---
V.S. Tough Tex	.05	1.84	---	---	---	---
V.S. CML Oil Base	.05	1.67	---	---	---	---
Kohl Madden Offset	.05	1.53	---	---	---	---
Xerox Bond						
Rubber Base Plus	.02	1.44	.03-.07	.02-.05	.02-.04	---
V.S. Tough Tex	.02	1.77	---	---	---	---
V.S. CML Oil Base	.02	1.65	.02-.04	.02-.04	.02-.04	---
Kohl Madden Offset	.02	1.41	---	---	---	---
Gilbert Neu-Tech						
Rubber Base Plus	.02	1.39	.02-.03	---	---	---
V.S. Tough Tex	.02	1.78	---	---	---	---
V.S. CML Oil Base	.02	1.68	.02-.05	.02-.03	.02-.03	---
Kohl Madden Offset	.02	1.45	---	---	---	---
Hammermill Offset						
Rubber Base Plus	.03	1.59	---	---	---	---
V.S. Tough Tex	.03	1.70	---	---	---	---
V.S. CML Oil Base	.03	1.67	.04-.08	.03-.07	.05-.07	---
Kohl Madden Offset	.03	1.53	---	---	---	---

Table 11. Density readings for all samples dried by forced air heat.

	Paper	SID	Rules	Type	Image	Tones
Xerox 4024						
Rubber Base Plus	.05	1.49	.09-.11	---	.09-.11	---
V.S. Tough Tex	.05	1.87	---	---	---	---
V.S. CML Oil Base	.05	1.65	.11-.19	.09-.18	.11-.17	.07-.10
Kohl Madden Offset	.05	1.54	.08-.11	.06-.10	.06-.09	---
Xerox Bond						
Rubber Base Plus	.02	1.49	.04-.06	.03-.05	.03-.05	---
V.S. Tough Tex	.02	1.76	---	---	---	---
V.S. CML Oil Base	.02	1.62	.15-.23	.07-.11	.05-.15	.03-.07
Kohl Madden Offset	.02	1.45	.06-.09	.03-.10	.04-.07	---
Gilbert Neu-Tech						
Rubber Base Plus	.02	1.39	.03-.06	.03-.07	.02-.04	---
V.S. Tough Tex	.02	1.75	---	---	---	---
V.S. CML Oil Base	.02	1.67	.08-.14	.06-.17	.07-.09	.03-.05
Kohl Madden Offset	.02	1.46	.05-.09	.08-.14	.06-.09	---
Hammermill Offset						
Rubber Base Plus	.03	1.69	.04-.05	.03-.04	.04	---
V.S. Tough Tex	.03	1.70	---	---	---	---
V.S. CML Oil Base	.03	1.67	.04-.06	.04-.07	.03-.05	.04
Kohl Madden Offset	.03	1.48	.04-.05	.04-.06	.03-.04	---

Table 12. Density readings for all samples dried by heating in a microwave oven.

	Paper	SID	Rules	Type	Image	Tones
Xerox 4024						
Rubber Base Plus	.05	1.53	.05-.08	.05-.06	.05-.06	---
V.S. Tough Tex	.05	1.75	.04	---	---	---
V.S. CML Oil Base	.05	1.73	.19-.24	.08-.14	.08-.11	.08-.09
Kohl Madden Offset	.05	1.47	.16-.20	.12-.17	.10-.13	.09-.11
Xerox Bond						
Rubber Base Plus	.02	1.47	.04-.08	.04-.06	.03-.05	---
V.S. Tough Tex	.02	1.79	---	---	---	---
V.S. CML Oil Base	.02	1.68	.19-.24	.06-.17	.07-.10	.03-.08
Kohl Madden Offset	.02	1.37	.12-.21	.07-.12	.10-.14	.03-.06
Gilbert Neu-Tech						
Rubber Base Plus	.02	1.37	.04-.06	.04-.06	.04-.06	---
V.S. Tough Tex	.02	1.78	---	---	---	---
V.S. CML Oil Base	.02	1.70	.10-.16	.10-.17	.10-.14	.04-.08
Kohl Madden Offset	.02	1.45	.19-.25	.10-.18	.11-.14	.07-.10
Hammermill Offset						
Rubber Base Plus	.03	1.55	.04-.06	---	---	---
V.S. Tough Tex	.03	1.75	---	---	---	---
V.S. CML Oil Base	.03	1.73	.09-.13	.05-.08	.06-.07	.03-.05
Kohl Madden Offset	.03	1.45	.04-.06	.05-.07	.03-.05	---

Table 13. Miscellaneous paper test data. Smoothness was measured on a Sheffield. Caliper was measured with a machinist's micrometer.

Xerox 4024 Dual Purpose	
Smoothness, felt side	158 Sheffield
Smoothness, wire side	150 Sheffield
Caliper	.493 micrometer
Xerox XXV Archival Bond	
Smoothness, felt side	149 Sheffield
Smoothness, wire side	158 Sheffield
Caliper	.494 micrometer
Gilbert Neu-Tech	
Smoothness, felt side	177 Sheffield
Smoothness, wire side	150 Sheffield
Caliper	.493 micrometer
Hammermill Offset	
Smoothness, felt side	151 Sheffield
Smoothness, wire side	149 Sheffield
Caliper	.494 micrometer